Essays on Market Conditions and Household Decisions: Internalizing Markets Through Farming Decisions & Social Networks.

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Dedication

To my family- especially my late grandmother Aji Rohey Kani Touray. Thank you for your love and support. We miss you dearly... but your spirit lives on and continues to keep us company.

Abstract

The objective of the chapters in this thesis is to examine the behavior of farming households in rural Ethiopia where the assumption of perfect markets may be violated by the presence of high transactions costs, thin and isolated markets, and missing markets for insurance among other goods or factors. Since farming households combine both producer and consumer aspects of microeconomic analysis, constraints to consumption decisions due to market failures are (or can be) relaxed through production decisions. This forms the basis of the agricultural household model formalizing non-separability of household decisions under market failures. Using this model, the forms of these responses and their effectiveness have been examined using data on farmers' choice of crops such as selection between food and cash crops; and composition of crop portfolio; and market participation decisions such as allocation of farm output to market exchange and household consumption; from several countries especially the developing world. These decisions are analyzed through the lens of farmers' efforts to internalize imperfect food markets through their farming decisions. In addition to production decisions, other responses take the form of informally designed strategies such as risk-sharing and state-contingent credit arrangements between households facing missing insurance markets. We consider the use of these strategies by farmers in rural Ethiopia using rich plot level data added to information about household characteristics (including social networks) and market/community infrastructure collected in repeated rounds of survey starting from 1989 through 2009. We find that non-separability or jointness in household decisions can be observed through farmers' crop choices and use of farm output. The extent to the non-separability of household decisions appears to be particularly sensitive to household characteristics such as size of food consumption and risk attitude; and market characteristics such as distance to market as well as community and market infrastructure. Informal risk-sharing arrangements through mutual support between households also exist in rural Ethiopia. It is observed that these informal insurance arrangements are highly persistent between relatives and neighbors.

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Contents

1 Introduction **1**

2 Market Conditions and Farmers' Crop Choices Under Possible Constraints on Household Consumption. **7**

2.1 Introduction . . . 8
2.2 Literature Review . . . 12
2.2.1 Production and Consumption Decisions of Agricultural Households: . . . 12
2.2.2 Conditions for Separability and Non-Separability of Household Decisions. . . . 14
2.2.3 Implications of Non-Separability on Production Decisions of Farming Households. . . . 15
2.3 Methodology . . . 23
2.3.1 Conceptual Framework . . . 23
2.3.2 Theoretical Model . . . 23
2.3.3 Estimation Models . . . 31
2.3.4 Data . . . 40
2.4 Results . . . 49
2.4.1 Household Level Analysis . . . 50
2.4.2 Plot Crop Choices- Food vs. Cash Crops . . . 58
2.4.3 Gains from Crop Diversification? . . . 63
2.5 Robustness Tests . . . 67
2.6 Conclusion . . . 69
2.7 Appendix . . . 71
2.7.1 Description of Variables . . . 71
2.7.2 Estimated Models . . . 71

3 Transactions Costs Effects on Farmers' Use of Farm Output: Market Exchange versus Household Consumption. **76**

3.1 Introduction . . . 77
3.2 Literature Review . . . 81
3.2.1 Price Changes, Market Participation & Transactions Costs . . . 82
3.2.2 Transactions Costs and Market Participation . . . 83
3.2.3 Identifying Transactions Costs Effects on Market Participation. 86
3.2.4 Responding to Transactions Costs Effects . . . 90
3.3 Methodology . . . 95
3.3.1 Conceptual Framework . . . 95
3.3.2 Theoretical Model . . . 96

3.3.3 Empirical Framework . . . 102
3.3.4 Data . . . 112
3.4 Results . . . 117
3.4.1 Transactions Cost Effects on Market Participation . . . 117
3.4.2 Heterogeneity of Transactions Cost Effects . . . 123
3.5 Robustness Tests . . . 129
3.6 Conclusion . . . 130
3.7 Appendix . . . 133
3.7.1 Description of variables . . . 133
3.7.2 Average Partial Effects for Cragg's Double Model. . . . 133
3.7.3 Dealing With Unobserved Heterogeneity . . . 134
3.7.4 Estimated Parameters from Cragg's Double Hurdle Model + Correlated Random Effects. . . . 135

4 Persistence of Links in Risk-Sharing Networks: Strategic Consideration versus Social Factors. 139
4.1 Introduction . . . 140
4.2 Literature Review . . . 145
4.2.1 Dealing with Risk and The Need for Insurance . . . 145
4.2.2 Informal Insurance Through Risk Sharing . . . 148
4.2.3 Risk-Sharing Networks . . . 152
4.3 Methodology . . . 156
4.3.1 Data & Conceptual Framework . . . 156
4.3.2 Theoretical Model . . . 164
4.3.3 Econometric Model . . . 169
4.4 Results . . . 175
4.4.1 Heterogeneity in the Persistence of Links . . . 181
4.5 Robustness Test . . . 191
4.6 Conclusion . . . 193
4.7 Appendix . . . 195
4.7.1 Description of Variables . . . 195

5 Conclusion 196

References 200

List of Tables

1 Summary Statistics: Round 9 Collected in 2009 . . . 42
2 Test of Means: Subsistence Vs. Food & Cash Crop Farmers: Round 9 . . . 45
3 Summary Statistics: Rounds 2-6 Collected between 1994-2004 . . . 47
4 Avg. Marginal Effects for Food Crop Production- Logit Estimation . . . 51
5 Avg. Marginal Effects for Crop Diversity: . . . 55
6 Avg. Marginal Effects for Crop Diversity (Food Crops) . . . 56
7 Avg. Marginal Effects for Plot Crop Choices- Logit Model . . . 59
8 Avg. Marginal Effects: Plot Crop Choices- Conditional Logit . . . 60
9 Gains from Diversification . . . 64
10 Description of Variables . . . 71
11 Food Crop only Production vs. Food + Cash Crops: Logit Estimation . . . 72
12 Tobit Estimation of: Diversity of Crop Portfolio . . . 73
13 Plot Crop Choices: Logit & Conditional Logit Estimation . . . 74
14 Plot Crop Choices: Mixed Logit Estimation . . . 75
15 Transactions Costs Indicators . . . 110
16 Summary Statistics: Selected Variables- Rounds 5-7 of ERHS (1999-2009) . . . 112
18 Test of Differences in Means of Sellers & Non-Sellers . . . 116
20 Transactions Costs Effects on Market Participation: Average Partial Effects . . . 118
21 Heterogeneity of Transactions Cost Effects on Marketing of Farm Output For Cash & Non-Cash Crop Farmers and Differences in Crop Diversity . . . 124
22 Description of Variables . . . 133
24 Transactions Cost Effects: Cragg's Double Hurdle Model . . . 136
25 Heterogeneity of Transactions Cost Effects: Cash Crop vs. Non-Cash Crop Farmers 137
26 Heterogeneity of Transactions Cost Effects: Diversity of Crop Portfolio . . . 138
27 Summary Statistics of Links in Risk-sharing Networks . . . 158
28 T-Test of Differences in Attributes of Persistence & Non-persistent Links in 2004 & 2009. . . . 163
29 Indicators of Strategic Consideration and Social Factors using Link Attributes . 172
30 Average Marginal Effects from Logit Estimation of Link Persistence . . . 176
31 Persistence of Links at Household Level (OLS & Tobit) . . . 177
32 Average Marginal Effects: Persistence of Sub-sample of Links (Kinship & Links with Neighbors) . . . 183
33 Average Marginal Effects: Persistence of Sub-sample of Links (Labor-Sharing & Financial Links) . . . 187
34 Robustness of Persistence of Links to Differences in Network Size due to Truncation . . . 192
35 Description of Variables . . . 195

1 Introduction

The thesis focused on examining the behavior of farming households in rural Ethiopia where the assumption of perfect markets may be violated by the presence of high transactions costs which constrain market participation decisions; thin and isolated markets creating price risk; and missing markets for insurance under high risk exposure thereby affecting farmers' ability to achieve food security and ensure consumption smoothing. Given that farming households combine both producer and consumer aspects of microeconomic analysis, their behavior under various assumptions about market conditions have been an interesting area of research culminating into a large body of literature. Combining Chayanov's concept of subjective equilibrium, Becker's allocation of time and other contributions from studies on farming-households, Singh et al. (1986d) have built the agricultural household model which combines both production and consumption aspects of a typical farming-household.

Using this model, various theoretical and empirical studies have emerged. In general, the theoretical contribution from this literature has shown that under well-functioning or perfect markets, the producer and consumer sides of the farming household are only linked through farm profits from production which are used to finance consumption decisions. This implies that production and consumption decisions can be modeled as though they are sequentially determined and farmers are price takers of exogenous market prices which equate to household shadow prices ensuring that household produced goods and owned factors are perfect substitutes to market goods. This is referred to as the separability of household decisions or the separable household model. On the other hand, under market failures such as the presence of transactions costs or other market features such as market isolation and missing markets, market prices no longer reflect farmers' valuation. The presence of a wedge between market and shadow prices due to market failures breaks the perfect substitutability of goods produced and/or factors owned by the household and similar market goods. This creates incentives for farmers to adjust their production decisions with consumption preferences in mind. As a result, household characteristics relating to consumption decisions such as demographics, size of food demand etc. affect production deci-

sions. This relationship has been attributed to constraints on household decisions such as their ability to balance household food demand, to substitute family with hired labor; to ensure consumption smoothing through borrowing among other effects. To relax these constraints, farmers have incentives to internalize markets which are missing or costly to participate. As a result, decisions relating to production and/or consumption decisions are determined by household shadow prices instead of exogenous market prices. This establishes jointness in the production and consumption decisions (which are no longer linked by farm profits only). This relationship between production and consumption decisions is the central pillar of the non-separable household model. This model shows that under market failures, farmers' adjust their production decisions such as their choice of crops and composition of crop portfolio; and their market participation decisions such as their allocation of farm harvest between market exchange and household consumption when the subjective equilibrium of the goods they produce and consume; and the factors they own and use; falls within the price bands imposed by market failures.

Several studies have empirically tested the implications of the agricultural household model under varying assumptions about markets. From tests of the (non)separability of household decisions; the substitutability of family and hired labor; to parametric approaches to estimate shadow prices, efforts to understand the behavior of farming households in developing countries continues to attract a lot of interest. As data quality improves, various forms of market failures are being identified along with the increased creativity of farmers as they devise mechanisms of operating under market failure. Farmers' responses to market failures- whether through their farming activities and/or their interactions with other households has been the focus of several recent studies. Janvry and Sadoulet (2006) call these responses "creativity in the context of adversity". These studies have used data relating to farmers' production decisions- such as crop choices, choice of farming technology; allocation of labor and farm harvest decisions among several others to examine the extent to which they constitute responses to constraints imposed by market failures. For instance, constraints on consumption decisions of a given household can be relaxed through production decisions such as the production of food crops rather than cash crops; and allocation of farm output for household consumption rather than market exchange. Across households, constraints imposed by missing

insurance markets can in principle be relaxed through repeated interactions between households resulting in informally designed insurance arrangements such as mutual support and other risk-sharing agreements.

Despite the developments in the theoretical and empirical literature on agricultural households, several gaps still exist. In a recent review of the literature on agricultural household models, Janvry and Sadoulet (2006), pointed out the gap in our understanding of the size of the extent to which the production of food crops instead of cash crops by subsistence farmers in developing countries is driven by concerns about food security relative to other factors which influence crop choices. Several studies have mostly focused on examining the extent to which observed production decisions reflect (non)separability of household decisions. The factors which drive the non-separability of production and consumption decisions; and the differences in the size of their influence have mostly been ignored in the literature despite its importance for the formulation of agricultural policy such as price incentives, subsidies among others. Another issue raised by LaFave and Thomas (2014) relates to limitations in data. Several studies on farmers' crop choices have used household level data leaving other factors such as plot characteristics (especially where farmers use multiple plots to farm different crops) which affect crop choices largely ignored. In terms of informal risk-sharing arrangements, several studies have mostly focused on examining the effectiveness of these arrangements with other issues such as the evolution of these arrangements overtime mostly ignored.

We take up these issues in the chapters of the thesis using plot-level crop choices and allocation of farm output combined with information on household and market characteristics (including household risk-sharing network) from farmers in rural Ethiopia. We examine the hypothesis that where constraints on household utility maximization due to market failures are binding, the resulting jointness in household decisions implies observed farming decisions such as crop choices and allocation of farm harvest between market exchange and household consumption are responses to relax the constraints. Other forms of these responses under missing markets include informal arrangements through social networks. Through farming decisions, households can internalize food markets through the production of

crops and allocation of farm harvest for household consumption rather than market exchange. Similarly, through repeated interactions between households, missing insurance markets can be internalized through systems of mutual support enforced by social norms among neighbors and family members.We test the first component of this hypothesis using data on farmers' choice of crops and diversity of crop portfolio into food and cash crops; allocation of farm output between market exchange and household consumption; and market conditions with indicators of transactions costs such as distance to markets, road conditions and market infrastructure. We investigate the extent to which farmers internalize food markets through their crop choices and use of farm output in the first and second chapters of the thesis respectively.

In the third chapter, we focus on the persistence of risk-sharing arrangements within household networks. Using data from two rounds of survey of household networks containing information about individuals on whom a given household relies on for support and their characteristics, we examine the extent to which the persistence of these arrangements between households overtime is influenced by strategic factors to maximize insurance or social factors such as altruism.

In the first chapter, we investigate the extent to which farmers' crop choices reflect non-separability of household decisions due to constraints on consumption decisions. The presence of market frictions such as transactions costs is likely to constraint households' ability to balance food demand through market exchange. For farming households, these constraints can be relaxed by internalizing food markets through crop choices- by producing food instead of cash crops. We test this hypothesis using rich plot-level panel data of farmers in rural Ethiopia to examine: farmers' choice of food and cash crops and the extent to which they diversify their crop portfolio. Under this hypothesis, farmers facing constraints on food demand have incentives to produce food crops for household consumption thereby reducing reliance on markets to balance household food demand. Thus, farmers' crop diversity (especially food crops) should reflect the extent to which food markets are internalized to achieve food security. We test this implication of the hypothesis through the effect of crop diversity on consumption using a panel data of the same farmers collected over ten years. Previous studies have mostly used household level data to examine crop choices of subsistence farmers. We

contribute to this literature by using rich plot-level data to examine the extent to which crop selection and diversity is influenced by simultaneity of household decisions. Furthermore, we also complement this analysis by estimating the effect of crop diversity on household consumption overtime.

In the second chapter, we investigate transactions costs effects on farmers' market participation through their use of farm harvest for market exchange and household consumption. We test the hypothesis that the presence of transactions costs constrains farmers' market participation by lowering returns from market exchange of farm output thereby increasing gains from alternative uses of farm harvest such as household consumption. Previous studies have largely focused on the effects of transactions costs on market exchange. However, for farming households facing joint determination of production and consumption decisions, transactions costs are likely to also affect farmers' use of farm harvest for household consumption. The second chapter makes a contribution in this regard. We also examine the heterogeneity of transactions costs effects across crop choices (categorized into cash and non-cash crops); and across farmers based on differences in diversity of crop portfolio. We test this hypothesis using three rounds of the Ethiopia Rural Household Survey (ERHS) data collected between 1999 and 2009.

In the fourth and final empirical chapter, we examine the persistence of links within risk-sharing networks of households in rural Ethiopia. Using two rounds of data collected over a five year period, we identify persistent links as individuals listed in both periods by households as their source of support in times of need. We investigate the extent to which the persistence of links in these networks are driven by strategic or social factors. Under strategic considerations, households are assumed to choose risk-sharing partners to maximize gains from insurance. On the other hand, risk-sharing arrangements between households (especially with family members and close neighbors) may persist overtime due to social factors such as altruism. We consider these explanations in the chapter using attributes of links in repeatedly observed risk-sharing networks in Ethiopia.

In general we find statistical evidence that indicators of household food demand such as the share of household expenditure allocated to food consumption; and

risk attitude have significant effect on farmers' choice of crops- especially in the production of food crops. We interpret this effect as concerns about food security and the likelihood of being constrained by market conditions creating incentives to internalize food markets. In terms of the allocation of farm harvest between market exchange and household consumption, it was observed that indicators of transactions costs such as distance to market lowers the volume of farm output sold and increases the proportion of household consumption obtained through farm harvest. On the other hand, improvements in roads and markets are associated with an increased volume of farm output used for market exchange; and a decrease in the amount use for household consumption. We interpret these results as the role of costly exchange of farm output due to transactions costs which create disincentives for farmers to participate in markets as sellers of farm output and possibly in making purchases for household consumption. Due to the relationship between production and consumption decisions for farming households, the production of food crops and the use of farm harvest for household consumption under binding constraints on market participation, is constrained-optimal since it enables households to internalize food markets.

Our analysis of the persistence of links in risk-sharing networks also shows that link attributes such as kinship relations, proximity (both in terms of neighborhood and farming area), connectedness of links and endowments (such as land) significantly influence the persistence of links in risk-sharing networks. Further examination of the persistence of specific links indicate that the effects of these factors differ in magnitude and statistical significance across links with family members and neighbors; as well as based on type of relationship- money-lending and labor sharing links.

2 Market Conditions and Farmers' Crop Choices Under Possible Constraints on Household Consumption.

Abstract

We investigate the extent to which farmers' crop choices reflect non-separability of household decisions due to constraints on consumption decisions. The presence of market frictions such as transactions costs is likely constraint households' ability to balance food demand through market exchange. For farming households, these constraints can be relaxed by internalizing food markets through crop choices-by producing food instead of cash crops. We test this hypothesis using rich plot-level panel data of farmers in rural Ethiopia to examine: farmers' choice of food and cash crops and the extent to which they diversify their crop portfolio. Under this hypothesis, farmers facing constraints on food demand have incentives to produce food crops for household consumption thereby reducing reliance on markets to balance household food demand. Thus, farmers' crop diversity (especially food crops) should reflect the extent to which food markets are internalized to achieve food security. We test this implication of the hypothesis through the effect of crop diversity on consumption using a panel data of the same farmers collected over ten years. Previous studies have mostly used household level data to examine crop choices of subsistence farmers. We contribute to this literature by using rich plot-level data to examine the extent to which crop selection and diversity is influenced by simultaneity of household decisions. Furthermore, we complement this analysis by estimating the effect of crop diversity on household consumption overtime. We find that the size of household food consumption significantly increases farmers' likelihood of specializing in food crops. A similar effect was also observed in farmers' selection of food crops at plot-level. Differences in risk-preferences also affect crop choices- with risk loving farmers being more likely to diversify their crop portfolio and select cash crops instead of food crops.

Keywords: *Crop choice, Ethiopia, farming households, markets, conditional logit, Poisson regression.*
JEL Classification: D130 O130 Q120

2.1 Introduction

The focus of the chapter is to investigate the extent to which farmers' crop choices are influenced by interdependence of household production and consumption decisions. Since farming households make production and consumption decisions, the nature of the interdependence between these decisions (whether joint or separate) has a significant implication on household behavior and hence observed choices. Under separate/sequential decisions, farmers choose optimal production decisions the returns from which are used to finance household consumption. However, under joint/simultaneous decisions, household production and consumption decisions are not only linked through farm profits/income, but also through the effect of consumption preferences on production decisions. Simultaneity of household decisions may result from market failures such as the presence of high transactions costs, thin and isolated markets and incomplete markets such as missing markets for insurance (especially where farmers are risk averse). The presence of these frictions in food markets, imposes constraints on household food consumption decisions. For farming households, these constraints can be relaxed by internalizing food markets through crop choices. Thus farmers facing binding constraints on household consumption have incentives to produce food crops and diversify their crop portfolio to reduce reliance on markets to balance household food demand.

We test this hypothesis in two ways. In the first part of the chapter, we use rich plot-level panel data of farmers in rural Ethiopia to examine the extent to which farmers' choice between food and cash crops; and diversification of crop portfolio reflect efforts to internalize food markets. We investigate the extent to which these decisions are constrained optimal responses to binding constraints on household food consumption through the effects of household and market characteristics. For farming households to internalize food markets through production decisions, observed crop choices are expected to be sensitive to household characteristics such as size of food consumption and risk-attitude; and market characteristics such as indicators of transactions costs to market participation. We examine the effects of these factors on the likelihood of farmers' specializing in food crops instead of producing cash crops, and the extent to which they diversify their crop portfolio (producing food and cash crops).. In addition to household-level crop choices,

and as a contribution to the existing literature we also consider farmers' plot-level choice of food and cash crops under the same hypothesis. With plot-level data, concerns about the effect of plot characteristics on crop choices and farmers' multiple crop choices across several plots can be captured.

Farmers' ability to relax constraints on household food demand through crop choices can also be examined through the effect of crop diversity on household consumption. Where food markets are internalized through crop choices, farmers with more diversified crop portfolios are expected to be less constrained by frictions in output markets and hence achieve food security. We test this implication of the hypothesis in the second part of the chapter through the effect of crop diversity on household consumption overtime using data collected in different intervals over a ten-year period to form a balanced panel. Crop diversity is constructed as an index of the number of food and cash crops produced by farmers in each farming period. To align the analysis in both parts of the chapter, the same set of households is considered in both pars of the chapter - except that in the first part, the data is available at plot-level whereas in the second part, we use household-level data.

Throughout our analysis, we define food crops as crops such as cereals that are produced predominantly for household consumption; whereas cash crops such as coffee are mostly produced for market exchange. In rural Ethiopia where a large number of the farmers are small-scale and rain-dependent, returns from farming represent a substantial portion of household income from which household consumption is financed. The Central Statistical Agency (CSA) of Ethiopia reports that there are 12.8 million small-scale farmers in Ethiopia cultivating 96.3% total land area yielding 95% of total agricultural production (Chamberlin and Schmidt (2011)). Furthermore, as in most developing countries, markets are often less integrated and incomplete with missing insurance markets and poorly developed credit markets. These conditions impose constraints on household decisions such as their ability to balance household food demand. For agricultural or semi-commercial households, the presence of these constraints establishes jointness/non-separability of production and consumption decisions. See Singh et al. (1986d); De Janvry et al. (1991a); Kurosaki and Fafchamps (2002); Taylor and Adelman (2003); Caillavet et al. (1994), among several others.

The chapter draws from the literature on the non-separability of household decisions in farming communities, and its implications on agricultural decisions. Several studies have examined the existence of jointness in household decisions and the extent to which it is driven by market conditions. Sadoulet and De Janvry (1995a) have shown that where market frictions such as transactions costs exist in output and/or input markets, the equality of shadow and market prices breaks. The inequality of prices imposes constraints on farmers' market participation and their ability to satisfy consumption decisions. This is a result of the breakdown of perfect substitutability of self-produced and market produced goods which is assumed in the absence of market frictions. However, through production decisions, farmers can relax these constraints by producing crops needed for household consumption thereby internalizing food markets. Similarly, the presence of price or yield risk in an environment with missing insurance markets breaks the equality of market and shadow prices. This is as a result of farmers' discount of expected output and prices due to risk aversion affecting both production and consumption decisions resulting in non-separability.

This hypothesis has been tested in several studies through factors influencing farmers' choice between food and cash crops; low-risk low return crops and high-risk high return crops; traditional and improved or hybrid varieties of crops among others Fafchamps (1992). Most of the studies on crop choices and its link with non-separability of household decisions use household level data in which farmers are classified into either food or cash crop producers. This approach ignores the effect of plot-specific factors which are likely to influence crop choices and the possibility of farmers' producing both food and cash crops on several plots. This chapter aims to contribute to the literature by using rich plot-level data in addition to the typical household level categorization of food and cash crop producers. Drawing from this literature we examine the hypothesis that farmers' choice between food and cash crops at plot-level is influenced by binding constraints on household consumption. We also complement this analysis by examining the effect of crop diversity at household-level on household consumption overtime using five rounds of data to form a balanced panel.

We find statistical evidence that the size of household food demand and risk-preferences significantly affect their choice of cash crops over food crops. Increase in food consumption (especially among more risk-averse farmers) significantly decreases farmers' probability of selecting cash crops relative to food crops. We also find that as farmers become more risk-averse, their likelihood of producing food crops increases. These results imply that under joint household decisions, farmers have incentives to produce food crops for household consumption thereby reducing reliance on markets to meet food demand. These gains are likely to ensure household food security as indicated by the positive effect of crop diversity on household consumption estimated using five rounds of household data. For risk-averse farmers with large food demand, gains from internalizing food markets may be larger than returns from cash crop production or specialization making their observed crop choices constrained-optimal.

2.2 Literature Review

Farming households make production, consumption, and labor allocation decisions to maximize profits and utility. Production decisions such as crop choices and composition of crop portfolio; consumption decisions such as choosing between consuming farm output or market goods, and labor allocations to agricultural and non-agricultural activities, use of family or hired labor; may be done jointly or sequentially. Joint household decisions imply that household decisions are non-separable and thus farmers make production decisions with consumption preferences in mind. On the other hand, under sequential decisions, farmers make production decisions to maximize profits followed by consumption and labor allocation decisions to maximize utility. Differences in household decision making process have both behavioral and policy implications, especially among subsistence farmers in developing countries. Several studies have examined production and consumption decisions of farming households with the objective of providing answers to questions such as:

- Are production and consumption decisions of farming households jointly or sequentially determined?
- What conditions influence the joint or separate determination of both decisions?
- How does the relationship between farmers' production and consumption decisions affect their behavior and its implication on agricultural policy?

The contribution of the chapter is linked to the latter aspect of the literature. We examine farmers' crop choices and the extent to which they are influenced by jointness of production and consumption decisions. By these decisions, we imply crop choices and household food demand respectively.

2.2.1 Production and Consumption Decisions of Agricultural Households:

In studying the behavior of subsistence farmers with regards to their production and consumption decisions, two approaches have been considered. The first

assumes that farmers make production decisions to maximize profits which are then used to finance consumption decisions to maximize utility. Through this sequential nature of household decisions, production and consumption sides of the household can be examined as being separately determined - hence the separable household model. On the other hand, the joint determination of household decisions implies farmers make production decisions while considering consumption preferences. This occurs where constraints on household consumption are relaxed through production decisions establishing jointness of both household decisions hence the non-separable household model.

Through this distinction, the extent to which observed production decisions such as farmers' choice of crops and production technology are profit maximizing can be examined to determine whether household decisions are separable or not. For farming-households, the separability of household decisions can be analyzed through the extent to which observed farming decisions are profit maximizing or in line with agricultural commercialization rather than other household objectives such as ensuring food security. This approach has been the basis for formulating testable hypothesis in several empirical studies on the separability of production and consumption decisions of farming households. In particular, farmers' choice between food and cash crops; or low-risk but low return and high-risk but high return crops, choice between improved and traditional varieties of inputs, and farmers' responses to exogenous price changes through supply and crop choices among several others have be examined through the hypothesis of separable of household decisions. On crop choices, see Von Braun and Kennedy (1986), Arslan and Taylor (2009) and Arslan (2011) for empirical examples. Similarly, the diversification of crop portfolio instead of specialization and the use of traditional instead of modern and yield improving inputs have been examined under the same hypothesis- see Morris (2007) for a recent review. Apart from crop choices, farmers' response to exogenous price changes have also been examined in the context of profit maximization in several studies. In particular negative and weak price elasticities of supply among farmers following policy interventions to increase market price are contrary to expectations- See Lau et al. (1978),Yoshimi et al. (1978) , Audavidhaya et al. (1984); Singh et al. (1986a) and Strauss (1984a).

These observations from production decisions of farmers and several other similar agricultural decisions suggest that understanding the behavior of farming households requires a first hand understanding of their decision making process. As such, identification of the conditions which influence separability or non-separability of production and consumption decisions becomes a fundamental preliminary step.

2.2.2 Conditions for Separability and Non-Separability of Household Decisions.

In the literature on agricultural households, the difference between separability and non-separability of household decisions has been attributed to market conditions and its effect on the substitutability of household and market produced goods.

On one end is a household model which assumes perfect markets - i.e. markets are able to provide perfect substitutes to household produced goods which implies equality of market and shadow prices. Other features of this assumption include the belief that markets are complete and competitive, free of market frictions such as significant participation/transactions costs to ensure perfect substitutability of farm output and market goods; family labor and hired labor; and on-farm and off-farm employment Singh et al. (1986d)Caillavet et al. (1994). This implies absence of transactions costs in the marketing of farm output; existence of credit, insurance, intermediate and other production related input markets. Under these conditions, production and consumption decisions can be modeled as if they are made separately since consumption decisions are unconstrained by market conditions. Hence, household decisions can be thought as a two-stage process- the first stage involves making production decisions to maximize profits; followed by consumption decisions to maximize utility. Analytically, these conditions create recursiveness in production and consumption decisions of farming households with profits from optimal production decisions used to maximize utility from consumption- hence the name *separable household* model.

On the other hand, the absence of perfect substitutes for household produced goods, adds a constraint to household consumption decisions. This occurs when market frictions such as transactions costs drive a wedge between shadow and market prices; or other factors which create a difference in utility from the consumption

of market and household produced goods creating a *missing* market. This issues have been discussed in a recent review by LaFave and Thomas (2014) and several other previous work [Neary and Roberts (1980); Singh et al. (1986b,c); Taylor and Adelman (2003); Caillavet et al. (1994); Coyle et al. (1994)]) challenging the validity of the perfect market assumption. These market conditions have been observed in rural communities of developing countries where markets are imperfect: often undeveloped with transactions costs and other frictions; and/or incomplete: missing insurance and credit markets; which constrain household decisions. The breakdown of perfect substitution creates an additional constraint on consumption decision- the inequality between market and shadow prices implies an endogenous budget constraint linking production and consumption decisions of farmers. As a result, households' ability to satisfy consumption decisions is affected. To relax these constraints, farmers may find it optimal to satisfy household consumption from own-farm output hence the simultaneity of production and consumption decisions in a *non-separable household model*.

Although the assumption of perfect markets has a significant bearing on the separability and non-separability of household decisions, this is only a sufficient condition but not necessary for household decisions to modeled as being separately determined. From the discussion above, it can be observed that separability is achieved when farmers are price takers (i.e. market prices are exogenous rather then endogenous shadow prices) and markets are used to execute transactions. This is often the case when frictions such as transactions costs; market attributes such as market isolation or less integration; and missing markets for insurance etc. are absent. It is for this reason that the non-separability of household decision is often examined along the lines of such market conditions.

2.2.3 Implications of Non-Separability on Production Decisions of Farming Households.

The conditions for non-separability of household decisions have been used to formulate testable hypotheses about agricultural decisions of farming households. For instance, under perfect markets, the separability of household decisions implies that households are price takers and only changes in exogenous factors such as market prices are expected to influence household decisions. Several empirical

studies have examined this hypothesis through the responsiveness of farm output (or marketed surplus) to changes in market price. Statistical evidence from these studies indicate negative and/or weak price elasticities which are contrary to the traditional Slutsky effect which is expected under separable household decisions and perfect markets. These results are explained in a non-separable household model as an endogenous household budget constraint resulting from a wedge between market and household shadow prices due to market failure. Since market prices of goods produced and consumed by the household; and factors owned and use by the household no longer reflect their respective subject/shadow prices, decisions relating to the marketing and consumption of farm output; and supply and demand of factors; are driven by shadow prices instead of market prices. As a result, household attributes (taste or preference shifters as they are often called) which influence shadow prices such as demographics, size of food consumption among others affect production decisions through shadow prices thereby establishing jointness of household decisions- (the profit effect-Yoshimi et al. (1978)). This creates possibilities of both positive and negative price elasticities- See Henning and Henningsen (2007) for a recent work on farmers' response to price changes. It is as a result of this that policy interventions such as price incentives which ignore market failures do not create desired impacts.

In addition to farmer's reaction to exogenous price changes, the implications of the assumptions underpinning the separable household model on household behavior have been examined through:

- Testing perfect substitution through households' choice between market and household-own goods (farm output and market goods for consumption; and hired versus family labor for household labor demand); and
- A parametric approach of testing equality of shadow and market prices as implied by perfect substitutability assumption of perfect markets.

The analysis of farming decisions examined through these approaches has been done by studying the extent to which market frictions such as transactions costs; or incomplete markets such as missing credit and insurance markets affect the

substitutability of market and household produced goods.

Transactions Costs Effects and Farming Decisions

The role of transactions costs in non-separable household models has been considered through its effect on marketing farm output. It has been argued that the presence of transactions costs lowers incentives for market participation by decreasing returns to market exchange of farm output which affect farmers' ability to satisfy consumption decisions- Renkow (1990), Goetz (1992a) among several others. Similarly, these costs may also trigger non-market frictions such as traditional and cultural factors (or subjective values as discussed in Arslan and Taylor (2009)), which affect shadow prices of farm output (such as seed quality preservation- a phenomenon also quite typical of African farmers) resulting in differences in utility and imperfect substitution between own-farm output and market goods. Recent findings by Bevis (2015) also showed that heterogeneity in nutrients content (zinc in particular) between home and market produced staple crops may drive farmers choice between market and household produced goods. These factors may quite possibly be an alternative explanation for farmer's choice of maize variety in the paper by Arslan and Taylor (2009)- in addition to subjectivity, choice of traditional varieties maybe constrained-optimal response to constraints imposed by transactions costs in the markets for improved varieties of maize.

The effect of transactions costs on the diversification of farming activities has also been studied. Omamo (1998a) examined the role of transaction costs in small scale farmers' decision to diversify or specialize in their agricultural production decisions using data from Kenya. Conceptually, when transactions costs impose binding constraints on market participation, anticipated efficiency gains from specialization in the production of certain crops could be undermined by disutility from costly participation in markets. Omamo modeled households' comparison of gains between specialization and diversification in the face of transaction costs using a General Algebric Modelling System (GAMS) which combines linear programming production system with a translog utility function. Focusing on distance to market as a measure of transaction costs[1], he found that as distance increases

[1]Search, bargaining and waiting costs are ignored largely due to their unobservable nature

(greater cost of participating in markets), inter-crop becomes the dominant technology of production. This implies that as trading costs rise, the opportunity cost of specialization rises making it more profitable to diversify production.
Similarly, Van Dusen and Taylor (2005) examined the effect of transactions costs in the form of distance to markets on farmers' decision to diversify crop choices using Poisson regression techniques on data from Mexico. They examined composition of farmers' crop portfolio (maize, beans and squash) and for each of these choices, the number of varieties selected using Poisson regressions to account for the discrete and count nature of farmer choices as defined above. Among the key findings was that improvement in market conditions (for instance more integration) lowers participation costs thereby reducing the likelihood of farmers diversifying crop choices since incentives to specialize increases.

Several other studies have examined the effect of transactions costs and other market frictions on household labor allocation decisions. Barnum and Squire (1979) examined the substitutability of household labor and hired labor when the former is allocated to off-farm work among farmers in Malaysia. A key result from their paper was that family labor was more likely to be replaced by remaining amount of family labor instead of using hired labor contrary to expectations of perfect substitutability of labor. Similar result was obtained by Rosenzweig (1980) in his study of labor allocation decisions among classes of land holding and land-less farmers in India. He further argued that the imperfect substitutability of family and hired labor maybe attributed to the inequality between shadow and market wages of labor driven by factors such as labor immobility especially among land holding households and women. Other studies on the imperfect substitution of family and hired labor have examined the of role of supervision costs as distortions to market and shadow wage equality in the use of hired labor as a substitute to family labor: Benjamin (1992), Lopez (1984, 1986) among others; and the effect of participation costs driven by low integration (isolated) and thin markets across space: Feder (1985) and Bardhan and Udry (1999). Under a non-separable household model, the presence of these frictions may affect both labor allocations and production decisions such as farmers' choice of less labor intensive crops.

Another approach to examine the assumption of perfect market involves para-

metric approaches used to estimate shadow prices. This motivated by the fact that perfect markets imply equality of shadow and market prices. Arslan and Taylor (2009) empirically estimated shadow prices of farmers' subsistence crops in Mexico focusing on two categories of maize farmers: users of traditional varieties and users of improved varieties; and commercial or non-commercial farmers[2]. They examined the equality of market and estimated shadow prices of traditional and modern varieties of maize produced by commercial and non-commercial farmers against the null hypothesis of equality as assumed in perfect markets. They failed to reject the null hypothesis for maize farmers using modern varieties. However for commercial and non-commercial traditional variety farmers, the null hypothesis was rejected. Thus, statistical evidence to support equality of shadow and market prices of traditional maize farmers was not found. The authors argued that inequality between market and shadow prices may be due to the existence of transactions costs in markets. This affects decisions of farmers by imposing price bands relative to shadow prices which ultimately determines their choice of maize market to participate. Similar techniques have also been applied on other farming decisions such as labor supply decisions: Lopez (1984); Jacoby (1993)[3],Benjamin (1992), Skoufias (1994) and Abdulai and Regmi (2000).

Missing Markets and Farming Decisions

Apart from transactions costs effects discussed above, the effects on market participation resulting in missing markets have also been considered in the literature. More formally, "...a market fails when the cost of a transaction through market exchange creates disutility greater than the utility gain that it produces, with the result that the market is not used for the transaction [resulting in missing markets]"(De Janvry et al. (1991a) p.1401)[4]. To examine the extent to which household decisions are affected by transactions costs, additional constraints are added to the household decision making process. In the case of production decisions, the presence of transactions costs such as search, bargaining and transportation costs etc. affect the marketing of farm output by lowering gains from market

[2]with commercial farming defined as farmers who sold more than 30% of their maize output

[3]Jacoby et al. (1988) is an earlier unpublished version.

[4]Stiglitz (1989) discussed the effect of imperfect information on product market failures in developing countries.

exchange. As a result farmers' decision to sell farm output is constrained by the extent to which market prices differ from farmers' valuation of farm output- i.e. their shadow price. This participation constraint is often formulated by specifying price boundaries which determine farmers' choice of participating or not.
Similarly, in the case of consumption decisions, the presence of transactions costs increase the cost of financing household consumption since market prices adjusted for transactions costs are higher. As a result, farmers' decision to purchase market goods for household consumption is constrained by the extent to which market prices differ from utility associated with consuming such goods. As a result, farmers' ability to balance household food demand is affected since participation in food markets may be costly[5].

In both production and consumption decisions, non-participation in '*formal*' markets is constrained-optimal under binding constraints to market participation. From the latter part of the statement mentioned above from De Janvry et al. (1991a), non-participation in this context occurs when farmers use or devise alternatives to formal markets in selling farm output and/or satisfying household food consumption thereby rending such markets *missing*. Under non-separable production and consumption decisions, this is synonymous to internalizing formal markets through household decisions. For instance, in the case of missing food markets, farmers may respond through crop choices and composition of crop portfolio by producing more of food crops. As a result, observed choice and diversity of crops, may constitute optimal responses to constrained consumption decisions. Thus, in the context of a utility maximizing framework, farmers' choice between food and cash crops can be examined as a function of relative differences between gains from internalized food markets through food crop production and profits from cash crop production. This provides a plausible explanation for farmers' choice of food crops over cash crops (even though the latter provides higher returns) and crop diversity as oppose to specialization which are widely observed in several developing countries (Von Braun and Kennedy (1986)).

In addition to these conditions, markets may also be incomplete. This occurs when

[5]Similar analogy can be extended to missing labor markets and the use of family labor; missing input markets such as fertilizer and seeds and the preservation of inputs across farming seasons.

markets for certain goods/services which are needed by farmers such as credit and insurance are absent- [Eswaran and Kotwal (1986, 1989)]. Incomplete markets affect farmers' ability to use efficient production technology due to credit constraints and concerns about risk in the use of new technology. Differences in households' risk bearing abilities as discussed by Ellis (1992) such as production and income risk Binswanger and Rosenzweig (1986) have differential effects on farmers and across different farming decisions. Mendola (2007) discusses the welfare implications of such market imperfections on farmers' choice of farming technology; Feder et al. (1985); Feder (1985) discuss the effect of risk introduced by volatility in farm output and prices due to low yield agricultural production technology; distant, thin and isolated markets; and weather shocks to yield; on production decisions. In a non-separable household model, incomplete insurance markets also affect production decisions through its effect on consumption. For instance, risk-averse farmers may choose to insure household consumption by producing food crops or low risk crops (Dercon (1996)); and to diversify rather than specialize in the production of a single crop. Fafchamps (1992) simulated large and small households' likelihood of selecting cash crops relative to food crops when households face multivariate risk. The paper explains farmer's choice of food over cash crops along the lines of the desire to ensure food sufficiency under imperfect markets and missing insurance markets. In this context, the imperfection of markets may stem from isolation of markets which creates volatility in food prices and ultimately farm income- the risk of which small farm households may not be able to sustain and thus find it optimal to satisfy household consumption before venturing into cash crop production. The higher net returns from cash crop production enable farmers to relax liquidity constraints especially where credit markets are missing.

In summary, the existing literature indicates that non-separability of farmers' production and consumptions decisions may be driven by market frictions such as transactions costs or incomplete and missing markets. These conditions result in the breakdown of the substitutability of household and market produced goods thereby constraining households' ability to balance its food demand. Responding to these constraints through production decisions establishes jointness of household decisions. This can be examined through farmers' choice of crops and the extent to which they constitute responses to constraints on household consump-

tion. Building on this, we consider two extensions:

- Using plot-level data to examine the extent to which farmers' choice between food and cash crops is influenced by constraints on household food consumption and the need to internalize food markets.
- Examining the extent to which gains from crop diversity under non-separable household decisions are reflected on household consumption using five rounds of data on farmers' crop diversity and consumption outcomes.

The first part of the chapter attempts to investigate the extent to which farmers' selection of food crops over cash crops constitute efforts to internalize food markets due to the presence of transactions costs which constrain household food demand. Previous studies have mostly used household level data. We use a rich plot-level data of crop choices, plot characteristics, household and community characteristics in a given farming season. The use of household-level data ignores plot-level characteristics which may significantly affect crop choices such as soil quality, plot sizes and other agronomic factors. This shortcoming has been stressed in a recent survey by LaFave and Thomas (2014). Household-level data also has limitations in it's applicability in environments where farmers produce multiple crops since the choice is only defined at household level. We also examine the hypothesis that farmers' respond to constraints on household food demand due to imperfect food markets through crop choices using alternative definition- crop diversity. In the presence on constraints on household food demand, diversification of crop production (especially food crops) constitutes a strategy to insure household food consumption and consumption smoothing. We test this hypothesis using five rounds of data containing a measure of crop.

2.3 Methodology

2.3.1 Conceptual Framework

We consider an environment where households' main economic activity is rain-fed, multi-crop farming. Under these conditions, observed crop choices may be influenced by constraints on household consumption due to transactions costs to market participation and/or risk-aversion to poor harvest due to rain variation. Where these constraints are binding, farmers are unable to balance their food demand through food markets. However, through crop choices and diversity, farmers can internalize food markets by producing crops needed for household consumption instead of other crops meant to market exchange. This possibility establishes jointness between farmers' production and consumption decisions. We test this hypothesis through: the factors influencing farmers' selection of crops: food versus cash crops; and scale of crop diversity. Food crops (mostly grains) are mainly used for household consumption whereas cash crops (mostly coffee) are mainly sold at exogenous market prices. Since farmers in this setting practice multi-cropping, we examine crop choices at plot-level and at household level- between subsistence farmers (producing food crops only) and non-subsistence farmers (producing both food and cash crops).

2.3.2 Theoretical Model

In a recent review of the literature on agricultural household models, Janvry and Sadoulet (2006) highlight a few guidelines including: modeling a household model with market failure requires a definition of specific form of market failure; and also that non-separability of household decisions is idiosyncratic in nature and not a market characteristic. As such responses to the resulting constraints imposed by market failures tend to vary across households. With these caveats in mind, we use plot-level data with household and market characteristics to examine farmers choice between food and cash crops and diversification of their crop portfolio into food and cash crops through the lens of responses to constraints on household food demand due to frictions in food markets such as high transactions costs. We assume that farmers' production decisions involve choice of crop(s), allocation of resources across the production of different crops-labor allocation and scale and choice of production technology- size of plots relative to total land endowment,

use of intermediate inputs etc. At household level, crop portfolio consists of food and/or cash crops. Consumption decisions on the other hand involve choosing quantity of own-farm produced goods, market goods and leisure. Non-separability of household decisions implies that we consider both decisions jointly.

Following (De Janvry et al., 1991a), we model farmers' production decisions to consist of: choosing between (and/or among) food and cash crops ($q_k^f$and q_k^c respectively) to produce on a given plot k, using family (own) labor-q_l^f, hired labor-$q_l^h$and other intermediate inputs such as fertilizer, seeds etc. which are differentiated based on source- household saved and market purchased:q_x^h, q_x^m respectively. Household inputs (family labor and saved intermediate inputs) and market inputs (hired labor and market purchased inputs) enter the production function separately to control for possible differences in productivity due to imperfect substitution under imperfect markets. More formally, this is expressed in the following production function at plot-level:

$$f_k\left(\mathbf{q};\mathbf{z},\mathbf{k}\right)=0 \tag{1}$$

which can take the form of Cobb-Doughlas production function with standard microeconomic assumptions: $\mathbf{q}$ is a vector of outputs with positive values $\left(q_k^f, q_k^c > 0\right)$ and inputs with negative values and convex $\left(q_l^f, q_l^h, q_x^h, q_x^m < 0\right)$. $\mathbf{z}$ and $\mathbf{k}$ are vectors of household and plot characteristics influencing production. Other standard microeconomic assumptions about the production function such as $f_k\left(.\right)$being continuous and twice-continuously differentiable everywhere in the interior of the production set and quasi-concavity apply. Although the chapter focuses on market failures in food markets, the possibility of similar conditions in input markets as highlighted in the literature review cannot be ruled out. As a result, in making input choices, farmers are likely to be constrained by missing markets for land and other intermediate inputs; the non-substitutability of family and hired labor; and saved and market purchased seeds among others in addition to the typical budget constraint to input choices. While we do not explicitly incorporate these issues in input markets in great detail, it is expected their effect on household welfare has implications on farmers' crop choices which is the main focus of this chapter. One implication from our assumptions about the production function is that farm-

ers exhaust their land endowments by dividing their total land endowment into a number of finite plots on which they produce different or the same crops. As a result, we define crop choices and production decisions at plot-level.

Farmers diversify activities by producing several crops in each farming period. Based on this definition, we measure crop diversity using information about the number of food crops $\left(q^f\right)$ and cash crops (q^c) produced by farmers in a given farming season. Crop diversity for each farmer is constructed as an index using the number of crops produced from a set of major food and cash crops in Ethiopia. Based on statistics provided by (Taffesse et al. (2011)), we define the set of food and cash crops as: $\jmath^f = \{teff, barley, wheat, maize, sorghum\}$ and $\jmath^c = \{coffee, chat\}$ which are used in the plot-level analysis of crop choices. The proportion of food and cash crops produced out their respective subsets is weighted to ensure that the index of crop diversity sums up to one. By this measure, diversity of crop portfolio increases with the number and type of crops produced.

$$\jmath_{\imath t} = \theta_f \left(\frac{\sum_{q^f=1}^{F} \left(q^f\right)}{\jmath^f} \right) + \theta_c \left(\frac{\sum_{q^c=1}^{C} \left(q^c\right)}{\jmath^c} \right) \tag{2}$$

Where $\jmath_{\imath t}$ is the measure of crop diversity for farmer $\imath$ in period t.; and θ_f and θ_c represent weights which sum up to 1.

We define farmers' consumption decision to be composed of: consumption of own-farm output-c_f; market purchased goods-$c_m$and leisure-c_l. Under perfect markets c_f and c_m are considered perfect substitutes and thus equally valued $(p_\imath = \bar{p}_\imath)$. This implies that the farmer becomes indifferent as to whether he/she obtains consumption goods from either farm harvest or market purchased. However, markets maybe characterized by frictions such as taxes, transactions costs, missing insurance markets under risk aversion, thin or isolated markets, and/or differences in production technology creating quality/valuation differentials between farm output and similar market goods-De Janvry et al. (1991a). The presence of these conditions drive a wedge between shadow and market prices of farm output resulting in inequality of prices $(p_\imath^* \neq p_\imath)$. As a result, markets are believed to fail or become imperfect since the substitutability of own farm output and similar market goods breaks down. This creates constraints on household consumption decisions

such as food consumption. Where these constraints are binding, farmers ability to balance food consumption between farm harvest (including previous endowment of the good such as stored food)- $(q_\imath + T_\imath)$; and market goods $(c_\imath)$ is affected. To incorporate this effect of market failure, household consumption decisions are separated into tradable goods and non-tradables. Tradables (T) represent goods for which perfect markets exist and their demand is expressed as a function of exogenous market prices. Non-tradales (NT) on the other hand represent goods for which markets fail as a result their demand and supply decisions are influenced by shadow rather than market prices. Example of NTs include food crops such as cereals which are available in the market but also produced by the household; whereas cash crops such as coffee which are produced largely for market exchange are examples of tradables. Therefore, consumption of non-tradable goods can be supplied by the household through farm harvest or purchased from the market. The extent to which farmers choose the former instead of the latter is expected to be sensitive to the constraints imposed by market frictions thereby affecting crop choices and creating jointness in household decisions. Tradable commodities (T) on the other hand represent household purchase of goods provided only by the market. Thus, these goods are by construction assumed to be exchanged in markets at exogenously observed prices. Households are assumed to be endowed with: time-T_l; land-$T_k = k, ..., K$; initial endowment of a given commodity $\imath$-$T_\imath$and exogenous source of income S.

Putting together farmers' production and consumption decisions as discussed above, the following utility maximization problem can be formulated subject to a set of constraints.

$$\max_{\mathbf{c},\mathbf{q}} U(\mathbf{c}, \mathbf{z}) \tag{3}$$

$$s.t. : \sum_{\imath \in T} p_\imath c_\imath \leq \sum_{\imath \in T} p_\imath (q_\imath + T_\imath) + S \tag{4}$$

$$\sum_{k \in T_k} f_k(\mathbf{q}; \mathbf{z}, \mathbf{k}) = 0 \tag{5}$$

$$p_\imath = \bar{p}_\imath \quad \imath \in T \tag{6}$$

$$q_\imath + T_\imath \geq c_\imath \quad \imath \in NT \tag{7}$$

where equation (4) represents the cash constraints on household tradables; equation (5) represents the constraint imposed by production technology on each plot owned by the farmer. Equation (7) refers to the equilibrium condition for all tradables which are valued at exogenous market prices. Equation (6) refers to the equilibrium condition for household non-tradables. Constraints on household consumption decisions due to market frictions such as transactions costs and missing food markets are formalized through farmers' ability to balance equation (7). The resulting Lagrangian from the constrained maximization is:

$$L = U(\mathbf{c}, \mathbf{z}) + \lambda \left[\sum_{\imath \in T} \bar{p}_\imath (q_\imath + T_\imath - c_\imath) + S \right] + \sum_{k \in T_k} \alpha_k \left[f_k(\mathbf{q}; \mathbf{z}, \mathbf{k}) \right] + \sum_{\imath \in NT} \theta_\imath (q_\imath + T_\imath - c_\imath) \tag{8}$$

The optimal solutions from the above maximization problem generates demand and supply functions for the household which are functions of prices and household characteristics relating to preferences- i.e. taste shifters. The demand functions illustrate farmers' decision regarding the quantity of goods to consume and inputs to use. Whereas the supply functions illustrate farmers' decision regarding quantity of farm output allocated to household consumption, market exchange and use as inputs. Under separable household decisions, all goods are valued at market prices since goods produced by the household are considered perfect substitutes with similar market goods. As a result, production and consumption choices specified above are profit and utility maximizing respectively with both linked only through farm profits from production which are used to finance household consumption. This implies that the farmer chooses crops to produce and factors to use to maximize revenue subject to a production function comprising of market prices, factors and production technology for the production side of the household; and chooses quantity of goods to consume to maximize utility subject to household budget constraints comprising of market prices and household income (which is often largely composed on farm income) for the consumer side of the household.

However, where market frictions such as transactions costs drive a wedge between

shadow and market prices of the non-tradables, households' ability to balance their food demand is affected. The difference between market and shadow prices of non-tradables creates endogeneity in the household budget constraint. Responding to this constraint by internalizing food markets through the use of farm output for household consumption rather than market exchange establishes jointness in household production and consumption decisions. As a result, household factors (rather than market factors in the case of separable household decisions) influence production decisions such as crop choices through their effect on shadow prices which replace market prices in the optimal demand and supply functions. Through household characteristics such as size of food demand and risk-attitude (especially in the absence of insurance markets), the inequality of shadow and market prices widens as constraints on household consumption become binding thereby increasing incentives to internalize food markets.

Since we model household decisions in this chapter as being jointly determined, the prices in the optimal demand and supply functions for tradables are the exogenous market prices since the markets for such goods are perfect and $(p_\imath = \bar{p}_\imath)\ \imath \in T$. On the other hand, due to market failures, household shadow prices influence the optimal demand and supply functions for non-tradables. Since $p_\imath \neq \bar{p}_\imath\ \imath \in NT$ for these goods, the shadow prices take the following form[6]:

$$p_\imath = p_\imath^* = \frac{\theta_\imath}{\lambda} \tag{9}$$

where $\theta_\imath$ is the marginal utility from relaxing household's ability to balance household food demand of non-tradables; and λ is the marginal utility from relaxing the budget constraint.

Several paradoxes observed among farmers especially in rural areas of developing countries have been largely attributed to the role of shadow prices under non-separable household decisions. For instance, the negative price elasticity of marketed surplus, the production of food crops rather than cash crops which offer higher market prices, diversification rather than specialization in crop production among several others have been attributed to the fact that the optimal supply decisions of farmers operating under market failures is the shadow rather than market

[6]Arslan and Taylor (2009) estimated shadow prices of maize producing farmers in Mexico. Under a strong assumption that labor markets are perfect, they showed how the shadow price can be estimated from its analytic relationship with market wages. Clearly, assuming perfect labor markets may be a strong assumption in the case of rural Ethiopia.

price. As a result, policy interventions such as price incentives, reallocation of land initiatives, provision of extension services etc which ignore market failures and by extension the wedge between shadow and market prices do not generate desired policy outcomes of increased agricultural commercialization and/or the production of cash crops.

The optimal demand and supply functions can be specified as an indirect utility comprising of household characteristics and prices. (De Janvry et al., 1991a) provide an analytic derivation of the optimal solution to the maximization problem in their paper which is similar to the setup in this chapter. Given that under non-separable household decisions, the shadow prices are also affected by household characteristics, the indirect utility specified for this households typically comprise of household and market characteristics- where the latter captures market frictions such as transactions costs and the extent of market integration which drive a wedge between market and shadow prices.

Preceding the supply decisions is farmers' choice of crops between food and cash crops and the composition of her crop portfolio ex-ante. Hence, optimal supply decisions are likely to be affected by farmers' crop choices ex-ante especially given that farmers are both producers and consumers. As a result, jointness of household decisions can be examined through the extent to which household characteristics affect farmers' choice between food and cash crops; and the extent to which they diversify their crop portfolio rather than specialize. To do this, we assume that farmers derive utility from their crop choices. Using the same structure of the indirect utility for optimal solutions described above, an indirect utility function comprising of household, market and plot characteristics can be specified for the observed crop choices in a given farming period. Through this setup, we examine the hypothesis that higher shadow price of farm output relative to market prices results in farmers deriving greater utility from satisfying household consumption from farm output and thus greater incentives to produce food crops relative to cash crops.

Similarly, constrains on household consumption may also lower gains from specialization such that farmers derive greater utility from ensuring food security by

diversifying crop portfolio. Under this hypothesis, indicators of household food demand such as size of food consumption should significantly affect farmers' choice between food and cash crops; and crop diversity should contribute to households' consumption smoothing. Other factors such as food prices, market accessibility (distance and transport conditions) and a combination of household and market characteristics should also significantly influence farmers' crop choices[7].

To empirically test this hypothesis, we express farmers' crop selection into a Random Utility Framework[8]. Therefore, choices can be modeled for household/farmer $\imath$ choosing crop choice $\jmath$ on plot k where $\jmath \in J = \left\{q_k^f, q_k^c\right\}$and q_k^f and q_k^c are set of food and cash crops respectively as defined above.

$$U_{\imath k}^{\jmath} = U\left(X_{\jmath}, Z_{\imath}, M_k\right) + \varepsilon_{\imath} \tag{10}$$

where $X_{\jmath}$ represents crop specific characteristics for a given crop $\jmath$; $Z_{\imath}$ represents household and community attributes for a given household $\imath$; and M_k represents plot specific attributes for a given plot k.

Supposing that $d_{\imath k,}^f = 1$ if household $\imath$ chooses food crop from q_k^f on plot k and 0 otherwise; similarly $d_{\imath k,}^c = 1$ if household $\imath$ chooses cash crop from q_k^c on plot k and 0 otherwise; such that at plot level, $d_{\imath k,}^f . d_{\imath k}^c = 0$[9], the indirect utility of the household at plot level can be represented as thus:

$$U_{\imath k}^* = U_k\left[d_{\imath k,}^f, d_{\imath k}^c | X_{\jmath}, Z_{\imath}, M_k\right] + \varepsilon_{\imath} \tag{11}$$

where $\varepsilon_{\imath}$ represents the unobservable component of the choice selection varying across households.

Across plots owned by a given household, total indirect utility for the household

[7]This approach builds on the typical test of separability and non-separability of household decisions established in the literature. Under separable household decisions, only market prices influence household production and consumption decisions. However, under non-separable decisions, non-market factors such as household attributes affect household decisions through its effect on household shadow and market price differentials due to market frictions such as transactions costs. See Taylor and Adelman (2003).

[8]See McFadden and Train (2000) for a discussion of how a Random Utility function can be used to capture unobservable taste/preferences in consumer decision making process. Also, Van Dusen and Taylor (2005) adopted similar framework in examining farmers choice to diversify crop choices under missing markets.

[9]This need not be the case at household level- the crop portfolio of households may contain both food and cash crops. Thus $d_{\imath k,}^f . d_{\imath \jmath}^c \neq 0 \; \forall k \neq \jmath \; \forall \imath$ is possible.

can be formulated as:

$$U_i^* = \sum_{k=1} U_k \left[d_{ik,}^f, d_{ik}^c | X_j, Z_i, M_k \right] + \varepsilon_i \tag{12}$$

2.3.3 Estimation Models

Equation (12) formalizes the representation of crop choices into a utility maximizing framework at household level. Using this expression, we can investigate the extent to which crop choices are driven by non-separability of production and consumption decisions resulting from constraints on household food demand due to frictions in food markets. This is done empirically by using techniques to approximate the utility expressed in equation (12) through various definitions of crop choices:

- Farmers' choice between food and cash crops in a given farming period.
- Farmers' diversification of crop production examined through an index of crop diversity in a given farming period.
- The effect of crop diversity on household consumption in repeated farming periods.

In all these models of crop choices, the focus of the analysis is on the effect of indicators of household food demand. The larger the household food demand, the more likely they are to be constrained by constraints due to market frictions such as transactions costs, and thus have more incentives of internalizing food markets. In the second part of the chapter, we examine the size of the effect of crop diversity on household consumption to illustrate the extent to which crop choices constitute effective strategies for farmers facing constraints on consumption.

Crop Selection: Food Crop vs. Cash crop

To estimate the utility farmers derive from observed plot-level crop choices in the context of the chapter, it is important to take into account the structure of the data. By defining crop choices as food and cash crops, a logit model can be fitted on plot-level data to obtain farmers' probability of selecting food crops relative to

cash crops.

However, in the data, a given farmer can have multiple plots generating multiple observations per household. In addition, farmers may also choose the same crop on different plots. Other factors worth considering in choosing an appropriate empirical technique include the role of unobservable factors (at household and community levels) which are likely to influence crop choices. It is for this reason that the utility function defined above follows a Random Utility Framework which as discussed in Train (2003) can be easily approximated by multinomial Logit Models.
In choosing an appropriate multinomial logit model, the structure of the data plays an important role. For instance, a Nested Logit model cannot be used due to the fact that farmers have multiple plots and thus make multiple choices. Similarly, differences in plot characteristics (such as slopes and soil quality) which differ across crops, introduce alternative variant attributes which cannot be incorporated using a multinomial logit model.

Following Cameron (2009)(ch.15), Greene (2003) and McFadden and Train (2000), the Mixed Logit Model[10] can account for: unobserved heterogeneity across alternatives such as plot and crop specific characteristics; and unobserved household preferences across crops. However, estimating a Mixed Logit model is computationally challenging since the likelihood function in a Maximum Likelihood estimation technique cannot be solved analytically but rather by simulation (Train (2003, 2008, 2009)).

An alternative to the Mixed Logit model is the Conditional Multinomial Logit Model due to McFadden (1980). The main difference between the two models being the Conditional Logit's assumption of Independence of Irrelevant Alternatives (IIA)- which implies that adding other alternatives does not change the relative probabilities of existing alternatives. Train (2003) discusses further that the IIA assumption implies that the stochastic component of a given alternative provides

[10]The Mixed Logit Model (a random effects estimator of the multinomial logit model) is an extension of the original Multinomial Logit model due to McFadden (1980) to relax the assumption of Independence of Irrelevant Alternatives (IIA) and also account for heterogeneity in choice selection.

no information about the stochastic component of another alternative. However, violation of this assumption can be corrected by one of three options as discussed by Train: 1) use an alternative model that captures the correlation in the stochastic component of the alternatives. 2) Respecify the error of each alternative to capture the correlated components leaving the uncorrelated component as white noise[11]. 3) Proceed with estimation of the model bearing in mind that the estimated model is at best an approximation of the representative utility function. (Train (2003) Ch. 3). The Mixed Logit model relaxes this assumption and allows for randomness in the parameters of the model to capture random taste variations due to unobservable factors[12].

In summary, the Mixed Logit model is an extension of the conditional logit model which relaxes the IIA assumption. However, the Mixed Logit is computationally challenging to estimate using Maximum Likelihood technique[13]. Using the Conditional Logit model requires reasonable justification of the validity of the IIA assumption. (Train, 2009) highlights that independence of unobserved characteristics over time and in repeated choices validates the IIA assumption. Although the possibility of repeated choice is maintained in the data, the objective of the chapter makes it easier to validate the IIA assumption. More precisely, given that the focus of the chapter is on the extent to which farmers' choice between food and cash crops (rather than choice of *individual* food and cash crops) are driven by constraints imposed by market conditions on household food demand, the choice set is defined by grouping individual crops. By this definition, it is reasonable to assume that stochastic components of one choice provide no information to the stochastic components of the other alternatives thereby validating the IIA assumption and the use of the Conditional Logit Model. Anecdotal evidence also shows that for most farmers in Ethiopia, a great proportion of food crop output is used for household consumption while cash crops are largely traded in markets thus the less likely degree of correlation.

[11]Such as the Mixed Logit model Train (2008).

[12]Hausman and McFadden (1984) propose a Hausman type test of the validity of the IIA assumption by comparing the log likelihood values of the original model and an re-estimated model without one of the alternatives.

[13]An attempt to fit the individual crop choices on a Mixed Logit model in Stata using the command developed by Hole (2007) building on an earlier work by Haan and Uhlendorff (2006), failed to achieve convergence after several specifications.

This strategy also has merits both theoretically and empirically. Theoretically, it is complicated to specify a utility function which captures factors which influence differences in utility between individual crops of the same category for instance two food crops such as maize and wheat. Furthermore, with a choice set defined at individual crop-level, different regions will quite possibly have different choice sets. Empirically, it is challenging to adequately control for differences in agronomic and environmental factors which result in different choice sets of crops across regions.
According to (Chamberlin and Schmidt (2011)) the major cereals produced in Ethiopia: teff, wheat, maize, sorghum and barley which account for three-quarters of total area cultivated, 29 percent of agricultural GDP in 2005/06 and 64 percent of calories consumed. Taffesse et al. (2011) also provided similar statistics. Other important crops identified by the report are: enset, oilseeds and pulses. Export/cash crops on the other hand are mainly coffee and chat with coffee accounting for 3.8 percent of GDP and chat generating 5 percent of total export earnings (Chamberlin and Schmidt (2011)). In addition to their respective contributions to aggregate agricultural output, the crops identified above also have very high yield per hectare with maize topping the list- 2500 kg/ha while wheat, barley and sorghum having yields in the range of 1200-1500kg/ha (Minot and Sawyer (2013)). In the data, the crops produced by farmers are teff, barley, wheat, maize, sorghum, enset, coffee and chat. Using survey statistics about agricultural production in Ethiopia provided in Chamberlin and Schmidt (2011), Taffesse et al. (2011) and Minot and Sawyer (2013), these crops can be grouped into food crops (mostly grain crops):teff, barley, wheat, maize, and sorghum; and cash crops:coffee and chat.

The utility function in (11) is defined at plot level for each household. However, for estimation purposes, crop choices as discussed above are categorized into groups: food and cash crops. This facilitates estimation of the following econometric specification of the Random Utility function by fitting a Conditional Logit Model on plot-level crop choices in a single farming season[14]:

[14](Long and Freese, 2006) illustrate the estimation of logit models in Stata.

$$Y_{\imath k}^{\jmath} = \mathbf{x}_{\jmath}^{'}\beta + \mathbf{z}_{\imath}^{'}\gamma + \mathbf{k}_{k}^{'}\rho + \varepsilon_{\imath k}^{\jmath} \qquad \jmath \in J = \left\{\jmath^{f}, \jmath^{c}\right\} \quad \forall k \tag{13}$$

where $Y_{\imath k}^{\jmath}$ takes the value of 1 for crop choice of a given group $\jmath$ on plot k such that:

$\jmath^{f} = \{teff, barley, wheat, maize, sorghum\}$ and $\jmath^{c} = \{coffee, chat\}$;

$\mathbf{x}_{\imath}$ is a vector of household factors such as information about food consumption, risk attitude, food prices, household demographics among others which affect crop choices; $\mathbf{z}_{\imath}$=vector of community attributes relating to market conditions which affect crop choices through their effect on household access to markets such as road conditions, distance to markets etc.; and $\mathbf{k}_{k}$= vector of plot characteristics which affect crop choices such as soil quality; β, γ, ρ being parameters to be estimated.

Following (Train, 2003), the unobserved component of each utility at plot level- $\varepsilon_{\imath k}^{\jmath}$is assumed to be $\imath\imath d$ extreme value distribution with a cumulative distribution function $F\left(\varepsilon_{\imath k}^{\jmath}\right)$ (with a variance $\frac{\pi^{2}}{6}$ necessary to normalize the scale of the utility function); and a density function $f\left(\varepsilon_{\imath k}^{\jmath}\right)$ both defined below.

$$F\left(\varepsilon_{\imath k}^{\jmath}\right) = \exp^{-\exp^{-\varepsilon_{\imath k}^{\jmath}}} \tag{14}$$

$$f\left(\varepsilon_{\imath k}^{\jmath}\right) = \exp^{-\varepsilon_{\imath k}^{\jmath}} \exp\left(-\exp^{-\varepsilon_{\imath k}^{\jmath}}\right) \tag{15}$$

The IIA assumption is implied by the independence of the unobservable component across alternatives. This means $\varepsilon_{\imath k}^{\jmath}$ of the utility from alternative $\jmath$ (for instance food crops) is unrelated to $\varepsilon_{\imath k}^{\ell}$ from the utility of alternative ℓ (cash crops for instance) for $\jmath \neq \ell$. The implication of this according to Train (2003) is that the observable component of the model facilitates a reasonable approximation of the utility function and unobservable component is essentially *'white noise'*.

For compactness, let the observable component of the choice selection be defined as: $V_{ik}^{\jmath\prime} = \left(\mathbf{x}_{j}^{'}, \mathbf{z}_{i}^{'}, \mathbf{k}_{k}^{'}\right)$;with the vector of parameters $\Psi_{ik}^{\jmath} = (\beta_{j}, \gamma_{j}, \rho_{j})$. The logit choice probabilities can be derived as shown below.

The probability that a given household $\imath$ chooses a crop of group $\jmath$ on plot k can be defined as:

$$\Pr_{ik}(\jmath) \quad = \quad Prob\left(U_{\imath k}^{\jmath} > U_{\imath k}^{\ell}\right) \forall\, \jmath, \ell \in J \; \jmath \neq \ell \tag{16}$$

$$= \quad Prob \quad \left(V_{ik}^{\jmath\prime} + \varepsilon_{\imath k}^{\jmath} > V_{ik}^{\ell\prime} + \varepsilon_{\imath k}^{\ell}\right) \forall\, \jmath, \ell \in J \; \jmath \neq \ell \tag{17}$$

$$= \quad Prob \quad \left(\varepsilon_{\imath k}^{\jmath} < V_{ik}^{\ell\prime} + \varepsilon_{\imath k}^{\ell} - V_{ik}^{\jmath\prime}\right) \forall\, \jmath, \ell \in J \; \jmath \neq \ell \tag{18}$$

Utilizing the independence assumption the cumulative distribution of all the alternatives becomes the product of the individual cumulative distributions. Therefore a given $\varepsilon_{\imath k\ell}$, the choice probability can be defined as:

$$\Pr_{ik}(\jmath) \mid \varepsilon_{\imath k}^{\jmath} = \prod_{\jmath \neq \ell} \exp^{-\exp^{-\left(V_{ik}^{\ell\prime} + \varepsilon_{\imath k}^{\ell} - V_{ik}^{\jmath\prime}\right)}} \tag{19}$$

Since $\varepsilon_{\imath k}^{\ell}$ is not given, the choice probability is the integral of $\Pr_{\imath k}(\jmath) \mid \varepsilon_{\imath k}^{\jmath}$ evaluated for all $\varepsilon_{\imath k}^{\ell}$ weighted by its density defined in (15):

$$\Pr_{ik}(\jmath) = \int \left(\prod_{\jmath \neq \ell} \exp^{-\exp^{-\left(V_{ik}^{\ell\prime} + \varepsilon_{\imath k}^{\ell} - V_{ik}^{\jmath\prime}\right)}} \right) \exp^{-\varepsilon_{\imath k}^{\ell}} \exp\left(-\exp^{-\varepsilon_{\imath k}^{\ell}}\right) d\varepsilon_{\imath k}^{\ell} \tag{20}$$

With further algebraic manipulations, the following closed form solution for the probability of choosing $\jmath$ on plot k by household $\imath$ can be obtained:

$$\Pr_{ik}(\jmath) = \frac{\exp\left(\Psi_{ik}^{\jmath\prime} V_{ik}^{\jmath\prime}\right)}{\sum_{\ell=1}^{\jmath} \left(\Psi_{ik}^{\ell\prime} V_{ik}^{\ell\prime}\right)} \tag{21}$$

for choice $\jmath$ such that $U_{\imath k}^{\jmath} > U_{\imath k}^{\ell}$for $\ell \neq \jmath$ and $d_{\imath k}^{\jmath} = 1$ for choice $\jmath$ and 0 otherwise. The Conditional Logit model can be estimated using maximum likelihood technique. The resulting Log likelihood function for (21) becomes:

$$\log L^{\jmath} = \sum_{\imath=1}^{N} \sum_{k=1}^{K} d_{\imath k}^{\jmath} \log\left[\Pr_{ik}(\jmath)\right] \tag{22}$$

Intensity of Crop Diversity

At household level, plot-level crop choices can be used to construct a measure of crop diversity defined in equation (2)- the number of crops of possible choices produced by a farmer in a given farming season. Under the same hypothesis being tested in the chapter, this measure can be examined in the context of farmers' response to constraints on household food demand. Farmers' facing binding constraints on consumption due to imperfect food markets, incentives to internalize food markets by diversifying their crop portfolio- especially food crops;

may outweigh gains from specialization. In addition, with missing credit markets imposing credit constraints to expand production; and missing insurance markets affect risk-averse farmers' production decisions, gains from specialization maybe further lowered. The latter is likely to strengthen incentives for food production through food security especially in a community where farming is mostly rain-fed[15].

Thus the combination of imperfect food markets and risky production under missing credit and insurance markets imply that the decision to diversify crop portfolio maybe driven by gains/utility farmers derive from ensuring food security. This occurs by internalizing imperfect markets and hence insuring consumption against risks due to rains and/or price volatility resulting from less integrated markets. We test this hypothesis by regressing our measure of crop diversity on household and market characteristics. Let $Y_\imath$ the measure of crop diversity for farmer $\imath$ expressed as a percentage using equation (2); $\mathbf{x}_\imath$ is a vector of household factors such as information about food consumption, food prices, household demographics among others which affect crop choices; $\mathbf{z}_\imath$=vector of community attributes relating to market conditions. Given that our measurement of crop diversity is constructed using an index ranging between zero and one; a two-limit Tobit model which accounts for the censoring on both the upper and lower limits is an alternative and is used.

$$Y_\imath = \mathbf{x}_\imath^{'}\theta + \mathbf{z}_\imath^{'}\vartheta + \xi_\imath \tag{23}$$

Testable Hypotheses:

Testing the hypothesis that farmers' selection of food and cash crops; and the diversity of their crop portfolio is driven by constraints on household food demand from the above estimation is done by examining:

1. the effect of indicators of household food demand on crop choices and crop diversity while controlling for other household attributes. Thus, it is expected

[15]Van Dusen and Taylor (2005) examines the effect of market conditions (such as distance to markets) on farmers' crop diversity. Similarly, in a recent paper Skoufias et al. (2017) examines household's occupational diversification between off-farm and on-farm; and across agricultural and non-agricultural sectors based on similar reasoning.

Porter (2012a) examined the effects of shocks due to rain and other idiosyncratic shocks such as illness and pests on consumption and income diversification strategies using the same earlier rounds of the data used in this chapter.

that households with larger food consumption are on average more likely to face binding constraints on food demand in the presence of transactions costs and thus have higher incentives of selecting and diversifying food crop production to reduce reliance on markets to balance household food demand. Similarly, in the absence of formal insurance, risk averse farmers have incentives of producing food crops relative to cash crops; and to diversify rather than specialize to ensure household food security. In testing this, we consider the size and significance of $\hat{\beta}$ and $\hat{\theta}$ from equations (13) and (23)- crop selection and diversity respectively.

2. the effect of indicators of transactions costs and other market frictions on farmers' choice between food and cash crops and on farmers' crop diversity. It is expected that farmers facing high transportation costs (measured through distance to market, road and transport conditions) or live in less integrated communities (measured through distance to major town) are on average more likely to be constrained by imperfect food markets or earn lower profits from cash crop production. It is expected that these farmers will on average have have higher incentives of producing food crops relative to cash crops and diversify food crop production. This is tested using the estimated parameters: $\hat{\gamma}$ and $\hat{\vartheta}$ from equations (13) and (23) for crop selection and crop diversity respectively.

Gains From Crop Diversification

To further investigate the extent to which non-separability of production and consumption decisions influences crop choices, we examine the effect of crop diversity on household consumption. While other consumption smoothing strategies for rural farmers exist, the use of agricultural diversification through the production of multiple crops across several plots is a common practice Alderman and Paxson (1994). In rural Ethiopia, the use of other strategies such as the accumulation and depletion of assets such as livestock; and informal insurance through risk-sharing arrangements are common risk-coping strategies. Empirical studies on the use of these strategies using the same data is found in Porter (2012a) and Hoddinott et al. (2009) respectively. The effectiveness of these strategies is often limited. For instance, poorly developed asset markets and the correlation of market price of assets

and shocks constrain the ability of farmers to smoothen consumption through the sale and purchase of livestocks Dercon (2000). Informal insurance arrangements such as risk-sharing between households and through semi-formal local associations often provide partial insurance against idiosyncratic shocks leaving covariate shocks largely uninsured. Therefore, to better minimize the effect of shocks, it is reasonable for farmers to use multiple risk-coping strategies which complement each other and also to internalize some markets. Through crop choices farmers' are able to reduce their reliance on markets to meet their food demand especially where market failures for food are typical. This can be complemented with the use of livestock and/or risk-sharing arrangements[16]. Under this hypothesis, gains from diversifying crop production should be reflected on household consumption as it insures households against consumption variation. In addition, through internalized food markets and the use of household production to satisfy consumption, the scale of crop diversity should have a large effect on household consumption. This can be tested through the effect and size of crop diversity on household consumption in repeated farming periods using a consumption smoothing framework as shown below.

$$\ln\left(C_{it}\right) = \alpha_0 + X_{it}^{P}\alpha_1 + \alpha_2 D_{it} + \alpha_3 D_{it} \bullet R_{rt}^{*} + \varepsilon_{it} \tag{24}$$

where $\ln\left(C_{it}\right)$ is the log of total household consumption per capita; X_{it}^{P} are household indicators of permanent income- such as livestock units (lagged to avoid endogeneity), total land area, etc.; and D_{it} is our measure of crop diversity; and R_{rt}^{*} is information about rainfall defined using the deviation of yearly rainfall at time period t from long-run community average for community r : $R_{rt}^{*} = \left(R_{rt} - \bar{R}_{r}\right)$ as done by Paxson (1992). This is done to capture transitory effect of rainfall on income. Since the data is constructed as a balanced panel, we estimate equation (24) using Fixed Effects estimator to account for unobserved heterogeneity across households. However, since the year intervals between the rounds of survey are uneven, we also use a pooled OLS estimator with time and community fixed effects and clustered standard errors to estimate equation (24). The parameters of

[16] In testing the extent to which crop diversity facilitates consumption smoothing, effort is made to capture the role played by livestocks. The use of informal insurance arrangements is examined in greater detail in chapter 4.

interest are: α_2, α_3 the effect of diversification on total household consumption.

Testable Hypothesis.

We test the hypothesis that farmers' diversification of crop production facilitates consumption smoothing by reducing reliance on markets to balance household food demand and ensuring food security by examining the effect of diversity on consumption through:

1. the size and significance of $\hat{\alpha_2}$and $\hat{\alpha_3}$for total consumption. Under the hypothesis, the net effect of crop diversity on consumption should be positive and significant. Households with more diversified crop portfolio are expected to be more consumption/food secure. For these farmers, shocks which affect returns from farming through lower crop yield due to rain variation, pest invasion etc.; or lower (higher) market price for farm output (market goods) such as price volatility are expected to have a lesser effect on household consumption since several food markets can be internalized through the consumption of output from various crops produced by the farmer.

2.3.4 Data

The data used is from the Ethiopian Rural Household Survey (ERHS) administered by the University of Addis Ababa, the Center for the Study of African Studies (CSAE) at the University of Oxford and the International Food Policy Research Institute (IFPRI). The survey is longitudinal household dataset which is representative of rural Ethiopia. Data collection started in 1989 with follow up rounds in 1994, 1995, 1997, 1999, 2004 and 2009. Over the years, the coverage of the survey has been expanded from an initial number of 6 administrative units to 15 across 4 of Ethiopia's 11 regions surveying 1,477 households. See Dercon (2004a) for a detailed discussion of the dataset. A description of each variable is provided in table (10) in the Appendix.

The first part of the chapter which examines farmers' crop selection and diversity uses the latest round of the survey collected in 2009. As a preliminary step, we use household-level data from this round to examine: the likelihood that a

given farmer produces food crops only (referred to as subsistence farmer) relative to a combination of food and cash crops (referred to as non-subsistence farmer); and factors which influence the intensity of farmers' crop diversity. We also use the plot-level data from this round, to investigate the factors which influence farmers' choice of food and cash crops. In total, the sample size consists of 802 households and 3,147 plots and crop choices[17].

The second part of the chapter which investigates the extent to which crop diversity affects household consumption uses five rounds of the data (rounds two through six) to form a balanced panel. In each round, a measure of crop diversity is calculated using the number of food and cash crops produced as defined in equation (2) and used to estimate its effect on household consumption.

Summary Statistics

Below we present a summary of the characteristics of households in the 2009 round of the survey which is used to examine crop choices. In addition, a summary of community infrastructure relating to market accessibility and plots characteristics are also reported.

[17]Households in the Northern Region of Tigray are excluded since they do not produce the cash crops considered in the chapter- coffee and chat.

Table 1: Summary Statistics: Round 9 Collected in 2009

Variable	Mean	Std. Dev.	Min.	Max.	N
Household Characteristics:					
Food Crop Only Farmer (=1)	0.488	0.5	0	1	802
Index of crop diversity	30.123	14.041	0	75	802
Index of food crop diversity	32.253	19.323	0	100	802
Hh. Food Share (lagged)	0.787	0.151	0.102	1	802
Risk	0.593	0.268	0	1	801
Hh. Land in Hec. (Lagged)	1.498	1.826	0	36.206	800
Hh. Number of plots	5.32	2.674	1	17	802
Hh. Size	5.964	2.534	1	16	802
Hh. Head Age	51.777	14.701	15	120	784
Male Headed hh. (=1)	0.668	0.471	0	1	802
Education yrs: No Schooling	0.459	0.499	0	1	802
Education yrs: Adult Lit.	0.188	0.391	0	1	802
Education yrs: Basic Educ.	0.281	0.45	0	1	802
Education yrs:Secondary Educ.	0.045	0.207	0	1	802
Education yrs: Higher Educ.	0.005	0.07	0	1	802
Community Infrastructure:					
Food Price Index (Lagged)	1.14	0.083	0.976	1.259	802
Better Transport (=1)	0.504	0.5	0	1	802
Better Roads (=1)	0.791	0.407	0	1	802
Distance to Mkt. (in Km)	2.914	3.091	0	11	802
Distance to Major Town (in Km)	8.799	6.310	3	25	802
Rainfall Deviation from avg.	60.785	58.321	-69.600	143.1	802
Plot Characteristics:					
Plot size (in Hectares)	0.528	3.759	0	200	3142
Soil Quality-Lem (v.good)	0.655	0.476	0	1	3147
Soil Quality-teuf (good)	0.081	0.272	0	1	3147
Soil Quality-Lem-teuf (avg.)	0.264	0.441	0	1	3147
Plot slope (Flat=1)	0.816	0.387	0	1	3147
Plot Slope (sloping=1)	0.168	0.374	0	1	3147
multiple crop plot	0.544	0.498	0	1	3147
cash crop (=1)	0.226	0.418	0	1	3147
Food crop (=1)	0.774	0.418	0	1	3147

The table above provides a summary of different attributes of households in the data. Characteristics such as the size of households' food consumption, risk attitude[18], land endowment, household size and attributes of its head indicate the extent to which constraints on household food consumption are likely to be binding and/or farmers' ability to internalize food markets through crop choices.

[18]Risk preferences are elicited from lotteries with outcomes defined in monetary terms (risk-money) and returns to market exchange (risk-market). We use these responses to construct a measure of risk preferences- 0=certainty; 1= risk loving; 0.25, 0.5, 0.75 represent values attached to choices with increased levels of risk but less than the risky choice. This is done separately for both outcomes which are then combined to construct a single measure of household risk-attitude.

The following observations are made about households in the data:

- On average, food consumption comprises of 78.7% of total household consumption.
- Farmers tend to diversify their crop portfolio by producing at least more than crop. Slightly more than half of the farmers in the data (51.2%) produce both food and cash crops.
- Apart from diversification of crops, farmers also use multiple plots-an average farmer has 5 plots with an average of 1.5hectares of land. Land endowment does not seem to vary significantly across households in the data as indicated by the small standard deviation. This is perhaps due to the fact that land is centrally distributed in Ethiopia.
- Average risk-preference of households is 0.596 on a scale of 0-1 where 0- risk averse and 1- risk-loving.

Similarly, community characteristics such as distance to market, transport and road conditions and distance to major town illustrate the extent to which constraints to market participation are likely to exist. This affects crop choices through farmers' ability to balance food demand directly or indirectly through incentives to produce cash crops. A couple of observations in the data include:

- The average distance to markets in the data is 3km. However, most farmers live in communities which are 9km away from a major town. This suggests that farmers are likely to face constraints in accessing major markets with more customers for agricultural produce and wide choice of household consumables.
- However, slightly more than half of the farmers live in communities with improvements in transport to other destinations; and upto 80% live in communities with improvements in road conditions. These developments are likely to lower transportation costs and other costs associated with market participation.

- Rainfall in 2008 was generally better than the average in previous years from most farmers in the data.

Jointly, this information is used to examine the extent to which farmers' choice between food and cash crops and the intensity of crop diversity (especially food crop production) is driven by market frictions which constrain household food demand. Under this hypothesis, differences in the attributes of subsistence and non-subsistence farmers can be examined in the context of the extent to which the constraints due to imperfect markets are binding and hence the need to internalize food markets. We examine these differences by conducting a t-test of household characteristics between farmers producing food crops only (i.e.. subsistence farmers) and farmers producing food and cash crops. The results are reported below:

Table 2: Test of Means: Subsistence Vs. Food & Cash Crop Farmers: Round 9

	Food & Cash Crop Farmer	Subsistence Farmer	Test of diff.
Variable	**mean**	**mean**	**p-value**
Household Characteristics:			
Index of crop diversity	38.970	20.823	0.000
Index of food crop diversity	23.317	41.645	0.000
Hh. Food Share (lagged)	0.770	0.806	0.001
Risk	0.629	0.555	0.000
Hh. Land in Hec. (Lagged)	1.056	1.965	0.000
Hh. Number of plots	5.100	5.552	0.016
Hh. Size	6.144	5.775	0.039
Hh. Head Age	52.303	51.229	0.307
Male Headed hh. (=1)	0.633	0.706	0.028
Education yrs: No Schooling	0.504	0.412	0.009
Adult Lit.	0.090	0.292	0.000
Basic Education	0.319	0.240	0.014
Secondary Education	0.056	0.033	0.121
Higher Edu.	0.005	0.005	0.960
Community Characteristics:			
Food Price Index (Lagged)	1.109	1.173	0.000
Better Transport (=1)	0.759	0.235	0.000
Better Roads (=1)	0.783	0.798	0.615
Distance to Mkt. (in Km)	3.199	2.615	0.007
Distance to Town (in Km)	7.321	10.352	0.000
Rainfall Deviation from avg.	67.192	54.051	0.001

A few striking differences between subsistence and food and cash crop farmers which relate to the key hypothesis of the chapter are summarized below:

- The average food consumption of subsistence farmers is higher than food and cash crop farmers. Under our hypothesis, this difference is likely to drive gains from producing food crops among subsistence farmers especially where constraints on food demand are binding. This possibility is further strengthened by the magnitude of food crop diversity among subsistence farmers which is also in line with empirical evidence that farmers in developing countries tend to produce cash crops only after producing sufficient amount of food crops for household consumption (Fafchamps (1992)).
- Food and cash crop farmers are more risk-loving on average. This is not surprising given that in an environment where farming is mostly rain-fed and formal insurance markets are missing, risk-averse farmers (especially towards

ensuring food security) are likely to produce low-risk low return crops such as food crops primarily for household consumption.

- On average, subsistence farmers have more hectares of land than food and cash crop farmers. Thus subsistence farmers' decision to produce food crops only does not appear to driven by smaller land endowment.

These differences which indicate that subsistence farmers have larger endowment, greater amount of food consumption and less risk-loving suggest that the decision to produce food crops maybe an indication of the non-separability of household decisions introduced by constrains on household consumption. Based on these characteristics, subsistence farmers' decision to produce food crops only may result from binding constraints on household food demand which may not be the case for other farmers. As a result, subsistence farmers have a greater need to internalize food markets and hence choose to produce food crops instead of cash crops.
Similarly, differences in community characteristics are also observed between subsistence and non-subsistence farmers. A summary is provided below:

- Although subsistence farmers live closer to markets than food and cash crop farmers, improvements in transport conditions are more common in non-subsistence farming communities.
- Also, food and cash crop farmers on average live closer to major towns and thus more likely to easily access larger and more integrated markets.
- Food prices in the subsistence farming communities are also higher compared to food and cash crop farming communities. This provides further incentives for subsistence farmers to produce food crops relative to cash crops.

In the second part of the chapter where we examine the magnitude of the gains from crop diversity, we use data on household consumption (including food share of total consumption); household livestock, land endowment and index of crop diversity. Also included is information about food prices. The data as summarized

below is obtained over ten-year period (between 1994-2004) i.e. 5 rounds of the ERHS data; from the same 802 households used in the first part of the chapter.

Table 3: Summary Statistics: Rounds 2-6 Collected between 1994-2004

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Total consumption	463.413	405.779	6.514	4823.598	4006
Food consumption	371.125	338.555	2.14	3499.899	4006
Food share (%)	0.802	0.152	0	1	4010
Real cons. per capita	73.416	65.188	2.387	731.732	4006
crop diversity	0.244	0.174	0	0.917	4010
food crop diversity	0.282	0.222	0	1	4010
Land area (in hectares)	1.339	1.2	0	16.25	3918
△Land area	-0.014	1.055	-12.75	13.25	2572
Number of plots	3.761	2.802	0	18	4010
num cash crop	0.414	0.627	0	2	4010
num food crop	1.689	1.334	0	6	4010
Number of crops	3.602	2.475	0	13	4010
△Number of crops	-0.289	3.174	-16	16	3361
△Number of plots	-0.244	2.751	-12	10	3361
Food price index	110.788	13.511	78.617	142.802	4010
Livestock Units	2.803	2.688	0	58.3	3633
Rain (deviation from avg)	0	241.304	-690.440	610.64	4010

As can be seen from above, food consumption represents a substantial portion of total household consumption- on average, 80% of household expenditure is allocated to food consumption. The production of food crops also appears to be a common practice. On average, farmers produce more food crops than cash crops as indicated by the average number of food crops produced (1.689) relative to cash crops (0.414); and the diversity in the number of food crops produced (0.282) compared to food and cash crops (0.244). Households have an average of 1.339 hectares of land. However land endowments appear to be fairly constant overtime. The consumption data is measured at household level at per adult equivalent using units provided by the World Health Organization (WHO) guidelines. The measure of food prices- The Food Price Index, was constructed using village level prices at the time of the survey. See Porter (2012a) and Dercon and Krishnan (1998) for a discussion of the construction of the consumption variables.

In general, farmers produce at least one food crop on multiple plots. Diversification of crop production is indicated by the index of crop diversity and average number of crops produced by farmers. Since food consumption constitutes a large

portion of household consumption, constrains on households' food demand are likely to have a significant welfare effect on farmers. The presence of other constraints due to absence of formal insurance markets and exposure to risk of rain variation and food price volatility create further incentives to internalize food markets by ensuring food security and minimize income risk through diversified crop production. The effectiveness of this strategy can be investigated through the effect of crop diversity on household consumption. This is the basis of the second part of the chapter.

2.4 Results

Under the hypothesis that crop choices of farmers are influenced by non-separability of household decisions due to constraints on food demand, indicators of the size of household food consumption, risk-attitude and indicators of market accessibility should significantly affect farmers' crop choices. We test this by estimating the following models:

- First, using household-level data, we examine the effect of household and community characteristics on the likelihood that a given farmer produces food crops only (i.e. subsistence farmer) relative to producing both food and cash crops;
- We then examine the effect of similar covariates on farmers' crop diversity measured using both weighted number of food and cash crops; and weighted number of food crops only produced estimated using a two-limit Tobit model.
- Using plot-level data, we examine the factors which influence the likelihood of producing cash crops relative to food crops on a given plot estimated using logit and conditional logit model.

More specifically, the test of the hypothesis is done through the analysis of:

- the individual effect of household food consumption on crop choices;
- the combined effects of household food consumption and risk attitude; and
- the combined effects of household food consumption and access to market indicators.

The focus on the effect of household food consumption, risk attitude and market characteristics follows the hypothesis being examined in this chapter which is built on the role of market failures in food markets and its effect on households' ability to balance its food demand. The interaction of household food consumption with risk attitude and indicators of market access is motivated by the work of Janvry

and Sadoulet (2006) in their review of agricultural household models. They highlighted the gap in our understanding of the relative differences in the magnitude of factors that affect farmers' production of food crops rather than cash crops. This involves examining various factors that affect crop choices to pin down the difference in the size of factors relating to risk of food insecurity relative to other determinants such as the presence of high transactions costs. We implement this by interacting the size of household food demand (which illustrates the extent to which the household is constrained by food market failures) with household risk preferences to capture the role of food security concerns; and with market characteristics which indicate participation costs and market integration to capture the effect of transactions costs and price risk. Another motivation for this approach is the fact that non-separability of household decisions is idiosyncratic (and not market) in nature. Therefore, responses to the resulting constraints are often heterogeneous even for households involved in similar activities. For this reason, we include both household and market characteristics in our analysis of crop choices and also examine differences in the diversification of crop portfolio across farmers in addition to choice between food and cash crops.

The second part of the chapter uses household panel data to examine the effect of crop diversity on household consumption estimated using pooled OLS and Fixed Effects estimators. We test this by examining the sign and significance of crop diversity on consumption.

The results from these models and the discussion of the results are provided below.

2.4.1 Household Level Analysis

Subsistence Vs. Food and Cash Crop Farmers.

We begin examining the extent to which crop choices at household level by estimating a logit model on farmers' likelihood of being a subsistence or food and cash crop farmer. We focus on the effect of indicators of household food consumption, risk attitude and accessibility to markets (which proxy for transactions costs) on farmers' likelihood of producing food crops only relative to food and cash crops. The average marginal effects obtained using Stata's *margins, dydx* command are presented below. The regression output from which the marginal

effects are obtained is provided in the Appendix.

Table 4: Avg. Marginal Effects for Food Crop Production- Logit Estimation

	(1)		(2)		(3)	
	Basic		**Food Share * Risk**		**Food Share * Markets**	
variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Household Characteristics						
Hh. Food cons. (lagged)	0.546***	(0.092)	0.565***	(0.094)	0.516***	(0.095)
Risk	-0.145***	(0.053)	-0.140***	(0.053)	-0.122**	(0.048)
Hh. Land in Hec. (Lagged)	0.016	(0.037)	0.0160	(0.037)	0.011	(0.022)
Hh. Number of plots	0.007	(0.007)	0.007	(0.007)	0.004	(0.006)
Hh. Head Age	-0.003**	(0.001)	-0.003**	(0.001)	-0.002*	(0.001)
Hh. Size	-0.009	(0.006)	-0.009	(0.001)	-0.007	(0.005)
Education yrs: Adult Lit.	0.038	(0.040)	0.041	(0.040)	0.052	(0.039)
Basic Education	-0.027	(0.040)	-0.026	(0.039)	-0.010	(0.036)
Secondary Education	0.006	(0.068)	0.003	(0.068)	0.043	(0.059)
Higher Edu.	-0.046	(0.110)	-0.039	(0.108)	-0.047	(0.113)
Male Headed hh. (=1)	0.088***	(0.034)	0.087***	(0.033)	0.071**	(0.030)
Mkt. & Community Factors						
Better Transport (=1)	-0.651***	(0.083)	-0.655***	(0.084)	-0.653***	(0.037)
Better Roads (=1)	-0.066	(0.044)	-0.065	(0.044)	-0.047	(0.032)
Distance to Mkt. (in Km)	-0.028***	(0.005)	-0.029***	(0.005)	-0.026***	(0.005)
Distance to Town (in Km)	-0.044***	(0.009)	-0.044***	(0.008)	-0.049***	(0.007)
Food Price Index (Lagged)	1.220***	(0.223)	1.230***	(0.224)	1.191***	(0.225)
Rainfall Deviation from avg.	-0.004***	(0.001)	-0.004***	(0.001)	-0.004***	(0.001)
Observations	781		781		781	
R-squared	0.397		0.399		0.457	
chi2	276.3		271.4		215.0	

Note: Dependent variable is a binary variable (=1 if farmer produced food crop(s) only; and 0 otherwise.
The specifications: 1=no interactions; 2= Food share and risk attitude; 3= Food share and mkt. characteristics
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

From the table above, it can be observed that households with larger share of expenditure on food consumption are more likely to produce food crops. All, else equal, increase in the proportion of household food expenditure is on average, associated with a 54.6% increase in the probability that a given farmer produces food crops only instead of food and cash crops. This effect is reinforced when household food consumption is combined with risk preferences- the net average effect of food consumption increases to 56.5%. However, conditioned on market characteristics such as distance to market, transport and road conditions and distance to major towns, the net effect of food consumption is smaller compared to the two other specifications.

In all the specifications, the size of household food consumption appears to have a large and statistically significant effect on farmers' choice between food and cash crops. Since crop choices are defined at household level in this model the effect of lagged household food consumption (which is assumed to be exogenous) can be analyzed through the extent to which observed crop choices constitute constrained-optimal response to constrained household food consumption. These constraints may result from market frictions such as transactions costs which affect households' ability to balance food consumption through market purchases; or due to missing insurance markets and risk-aversion of farmers. Under these conditions, risk-averse farmers with high proportion of expenditure allocated to food consumption are more likely to face binding constraints on their food demand. The presence of these constraints breaks the substitutability of market and farm output thereby affecting households' ability to balance food consumption through market purchases. Rather than relying on markets for household food consumption, households for whom these constraints are binding have incentives to internalize food markets through crop choices. These gains appear to increase with the degree of risk-aversion and size of household food consumption. By producing food crops only (rather than food and cash crops), farmers are able to satisfy household food consumption through farm harvest instead of market exchange. This minimizes consumption risk due to food price volatility and ensures food security since the food crops considered in this chapter are typically low risk due to their resistance to adverse climatic conditions. The resulting utility from internalized food markets may outweigh market returns from cash crop production (net of transactions costs) and in the presence of subjectivity towards own-farm output, yield higher utility compared to the consumption of market goods. Where grains from the latter are substantial such that farmers strictly prefer balancing household food demand through own-farm output instead of market purchases, missing food markets are discussed in De Janvry et al. (1991a) are created resulting in non-separability of household decisions.

Another interesting result from the table above is the effect of risk preferences on farmers' likelihood of being a food crop only producer. On average, more risk-loving households are less likely to be food crop only producers- the average marginal effect is 14.5%. As highlighted above, under the premise that the

production of food crops facilitates households' ability to balance food demand, non-separability of household decisions occurs especially among risk-averse farmers. Subsistence farmers may be risk-averse towards fluctuations in household consumption and thus produce food crops to ensure food security. Furthermore, where formal insurance is not available, credit constrained farmers engaged in rain-fed agriculture face risk of poor yield due to rain variation and price risk due to poorly developed and less integrated markets. These conditions lower incentives for cash crop production and affect farmers' ability to maximize utility from consumption financed by returns from farming. Under these climatic conditions, investments in cash crop production may be risky compared to the production of food crops which are resistant to rain-variation, pests etc. As a result, risk-averse farmers resort to producing drought-resistant, low-risk, low return crops only- a characterization which fits the profile of most food crops. To further substantiate the significance of household food demand on crop choices, it can be observed that the net average effect of risk preferences is smaller when household food consumption is combined with risk and even smaller when food consumption is interacted with indicators of market access. Thus while risk-loving farmers are more likely to be involved in cash crop production, the effect is sensitive to differences in the share of food consumption across farmers. Therefore, concerns about household food security (as indicated by the size of household food consumption) are likely to dampen the extent to which risk-loving farmers choose cash crops.

Differences in community characteristics relating to market accessibility also appear to influence farmers' likelihood of specializing in food crop production relative to producing food and cash crops. Community infrastructure especially improvement in transport conditions significantly influence farmers choice of crops. The average marginal effect from the table shows that farmers in communities with improved transportation are 65.3% less likely to specialize in food crops only relative to farmers in communities without such improvements. The effect of improvements in road conditions is similar, albeit smaller in magnitude and statistically insignificant. These improvements are likely to lower transactions costs thereby making constraints to market participation to purchase household consumables or exchange farm output (such as cash crops) less binding. See Jayne (1994) and Omamo (1998a) for similar studies. However, distance to market and major towns

are both associated with a decrease in the likelihood of farmers specializing in food crops only relative to producing food and cash crops. This is surprising given that increase in distance to markets (within the community or nearest market outside the community) implies higher transactions costs all else equal and hence lower gains from cash crop production. However, this effect is independent of the state of transport and road conditions which are likely to dampen the effect of distance on transactions costs and hence crop choices.

At community level, farmers facing higher food prices are also more likely to specialize in food crop production relative to a combination of food and cash crops. This is perhaps because food price inflation (or volatility as studied by Fafchamps (1992)) lowers farmers' ability to meet household food demand thereby increasing grains from producing food crops. This effect is likely to be more pronounced in communities where farmers face other constraints on food consumption due to market frictions. Under these conditions, incentives to produce food crops for household consumption are likely to be higher than gains from market returns from cash crop production.

Crop Diversity

The analysis above focuses on crop choices at household level defined as farmers' likelihood of specializing in food crops or producing food and cash crops. However, with plot-level data and given that farmers produce multiple food and/or cash crops across several plots, the diversity in farmers' crop portfolio can be measured. Using two measures of crop diversity: producing a combination of food and cash crops; and producing several food crops, we examine the factors which influence the extent to which farmers diversify their crop choices with a focus on the effect of household food consumption, risk-attitude and market conditions. The marginal effects from the tobit model are presented below for all three specifications for each measure.

Table 5: Avg. Marginal Effects for Crop Diversity:

		Basic		Food Share * Risk		Food Share * Markets
variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Household Characteristics						
Hh. Food cons. (lagged)	-10.446***	(2.936)	-10.673***	(2.937)	-9.391***	(2.924)
Risk	2.306	(1.815)	2.233	(1.831)	1.753	(1.80)
Hh. Land in Hec. (Lagged)	-0.130	(0.447)	-0.135	(0.448)	-0.031	(0.395)
Hh. Number of plots	1.656***	(0.218)	1.658***	(0.218)	1.679***	(0.216)
Hh. Head Age	0.030	(0.033)	0.030	(0.033)	0.017	(0.034)
Hh. Size	0.191	(0.202)	0.192	(0.202)	0.193	(0.20)
Male Headed hh. (=1)	-0.132	(1.130)	-0.109	(1.130)	-0.126	(1.112)
Education yrs: Adult Lit.	-0.923	(1.309)	-0.936	(1.315)	-0.877	(1.30)
Basic Education	-0.555	(1.321)	-0.571	(1.321)	-0.612	(1.298)
Secondary Education	-1.374	(2.861)	-1.329	(2.843)	-1.489	(2.847)
Higher Edu.	0.037	(4.154)	-0.064	(4.217)	0.519	(4.110)
Mkt. & Community Factors						
Better Transport (=1)	12.079***	(2.011)	12.054***	(2.017)	12.962***	(1.937)
Better Roads (=1)	5.858***	(1.394)	5.862***	(1.393)	6.337***	(1.384)
Distance to Mkt. (in Km)	0.745***	(0.193)	0.751***	(0.193)	0.870***	(0.210)
Distance to Town (in Km)	0.630***	(0.203)	0.627***	(0.204)	0.855***	(0.222)
Food Price Index (Lagged)	-2.123	(8.288)	-2.407	(8.310)	1.1788	(8.376)
Rainfall Deviation from avg.	0.054**	(0.023)	0.053**	(0.023)	0.0819***	(0.025)
Observations	781		781		781	
R-Squared	0.0361		0.0361		0.0394	
log likelihood	-3042		-3041		-3031	

Note: The dependent variable is a measure of crop diversity (i.e both food and cash crops) ranging btw 0-100.
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Diversification of Food Crops

In addition to total crop diversity (food and cash crops), we also examine farmers' food crop diversification.

Table 6: Avg. Marginal Effects for Crop Diversity (Food Crops)

		Basic		**Food Share * Risk**		**Food Share * Markets**
variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Household Characteristics						
Hh. Food Share (lagged)	13.137***	(3.424)	-3.961*	(2.214)	12.998***	(3.803)
Risk	-4.10*	(2.206)	-0.097**	(0.043)	-3.640*	(2.123)
Hh. Land in Hec. (Lagged)	0.326	(0.341)	0.334	(0.343)	0.266	(0.317)
Hh. Number of plots	2.939***	(0.258)	2.936***	(0.258)	2.914***	(0.252)
Hh. Head Age	-0.098**	(0.043)	13.519***	(3.508)	-0.086**	(0.043)
Hh. Size	0.258	(0.258)	0.256	(0.258)	0.230	(0.253)
Male Headed hh. (=1)	4.850***	(1.396)	4.812***	(1.392)	4.814***	(1.385)
Education yrs: Adult Lit.	1.944	(1.702)	1.965	(1.700)	2.151	(1.689)
Basic Education	-2.505	(1.587)	-2.482	(1.584)	-2.617*	(1.575)
Secondary Education	0.309	(3.538)	0.241	(3.546)	0.702	(3.491)
Higher Edu.	3.497	(10.046)	3.652	(9.923)	3.423	(9.999)
Mkt. & Community Factors						
Better Transport (=1)	-23.451***	(1.931)	-23.409***	(1.931)	-24.019***	(1.923)
Better Roads (=1)	10.546***	(1.638)	10.542***	(1.636)	10.787***	(1.687)
Distance to Mkt. (in Km)	-0.376**	(0.189)	-0.387**	(0.191)	-0.420**	(0.211)
Distance to Town (in Km)	-1.911***	(0.201)	-1.905***	(0.201)	-2.000***	(0.220)
Food Price Index (Lagged)	-22.771***	(8.035)	-22.313***	(8.008)	-25.345***	(8.027)
Rainfall Deviation from avg.	-0.261***	(0.020)	-0.259***	(0.020)	-0.273***	(0.0229)
Observations	781		781		781	
R-Squared	0.0752		0.0753		0.0788	
log likelihood	-2997		-2997		-2943	

Note: The dependent variable is a measure of food crop diversity (i.e various food crops) ranging btw 0-100.
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Similar to household level crop choices, the size of households' food consumption has a statistically significant effect on farmers' crop diversity. It is observed that as the size of household food consumption increases, the extent to which farmers' diversify crop production by producing both food and cash crops decreases. However, the opposite effect is observed when crop diversity is restricted to food crops only- increase in food consumption is associated with an increase in farmers' diversification of food crops. The average marginal effect of an increase in food consumption is: a 10.446% decrease in crop diversity (i.e. the extent to which farmers producing food and cash crops where 100 implies producing all food and

all cash crops in the set of crops used); and a 13.137% increase in food crop diversity (i.e. the extent to which farmers produce food crops where 100 implies producing all food crops in the set of crops used). Similar to our analysis of household crop choices, households with larger food consumption are likely to be more constrained by market frictions in output markets and thus have more incentives to produce more food crops, all else equal. By producing several food crops (instead of producing both food and cash crops), these farmers are more easily able to internalize food markets and hence reduce their reliance on food markets to balance household food demand. This effect is however, independent of household risk-preferences. This is shown in the second specification of food crop diversity where the combined effect of risk and food demand on farmers' crop decisions is captured. The net effect of food demand on food crop diversity is negative- increase in food consumption conditional on household risk attitude lowers food crop diversity. As with the analysis of household crop choices, this result illustrates the extent to which the effect of household food consumption on farming decisions is sensitive to differences in risk preferences across farmers.

On average, risk-loving farmers are more likely to diversify crop production by producing both food and cash crops. Although, this effect is statistically insignificant, the effect of risk on food crop diversity is statistically significant and negative. It is perhaps because of this that the net effect of household food consumption when interacted with risk on food crop diversity is negative i.e. risk-loving attitude is generally associated with a decrease in the diversify food crop production. It is important to stress that the effect of risk on crop diversity through the production of food and cash crops; and through the production of several food crops maybe sensitive to the fact that the food crops considered in the chapter are generally low risk low-return crops. As a result, the marginal cost (or risk of losses) associated with adding a food crop to a crop portfolio is small and hence the statistically insignificant effect of risk attitude on producing food and cash crops. Similarly, because risk associated with producing food crops is small, risk-loving farmers can easily specialize in the production of food crops whereas risk-averse farmers choose to produce several food crops as shown by the statistically significant effect of risk on food crop diversity. Therefore, it is perhaps because of the differences in risk inherent in food and cash crops that household risk-attitude has a different effect

on farmers' diversity of crop choices.

The effect of community characteristics is similar to what is observed in the analysis of household level crop choices. Improvements in infrastructure such as transport conditions and road networks are on average associated in with an increase in crop diversity. The effect is even larger when the combined effect of food consumption and market accessibility on crop diversity is captured. It is equally not surprising that such improvements are associated with a decrease in food crop diversity since the effect of lower transactions costs resulting from improved market access is likely to boost the incentives for cash crop production (due to higher market prices) and hence the need to diversify crop portfolio. Similar to the results above the effect of distance to market and major town are both smaller and contrary to expectations. This might be as a result of the fact that transport and road conditions have a greater effect on transactions costs than distance to markets and hence the counter intuitive effect.

2.4.2 Plot Crop Choices- Food vs. Cash Crops

In addition to household level crop choices, we also examine crop choices at plot-level by estimating a logit model on farmers' choice of food and cash crops. However, to capture the fact that a given farmer makes multiple choices on several plots, we also use a conditional logit model.

Logit Model:

Table 7: Avg. Marginal Effects for Plot Crop Choices- Logit Model

		Basic		Food Share * Risk		Food Share * Markets
variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Household Characteristics						
Hh. Food Cons. (lagged)	-0.315***	(0.047)	-0.320***	(0.048)	-0.302***	(0.050)
Risk	0.098***	(0.030)	0.095***	(0.029)	0.092***	(0.029)
Hh. Size	0.002	(0.003)	0.002	(0.003)	0.002	(0.003)
Male Headed hh. (=1)	-0.071***	(0.018)	-0.0703***	(0.017)	-0.068***	(0.017)
Hh. Head Age	0.001**	(0.001)	0.001**	(0.001)	0.001*	(0.001)
hh. Number of crops	0.021***	(0.003)	0.021***	(0.003)	0.020***	(0.003)
Hh. Number of plots	-0.038***	(0.004)	-0.038***	(0.004)	-0.035***	(0.004)
Hh. Land in Hec. (Lagged)	-0.007	(0.001)	-0.007	(0.010)	-0.005	(0.008)
Education yrs: Adult Lit.	-0.021	(0.026)	-0.022	(0.026)	-0.023	(0.026)
Basic Education	0.007	(0.022)	0.007	(0.022)	0.007	(0.021)
Secondary Education	-0.030	(0.038)	-0.030	(0.038)	-0.042	(0.037)
Higher Edu.	0.044	(0.082)	0.045	(0.082)	0.042	(0.083)
Mkt. & Community Factors						
Food Price Index (Lagged)	0.261**	(0.122)	0.260**	(0.122)	0.290***	(0.113)
Distance to Town (in Km)	0.024***	(0.003)	0.024***	(0.003)	0.025***	(0.003)
Better Roads (=1)	-0.052**	(0.025)	-0.052**	(0.025)	-0.090***	(0.032)
Distance to Mkt (in Km)	0.017***	(0.003)	0.017***	(0.003)	0.019***	(0.003)
Better Transport (=1)	0.366***	(0.037)	0.366***	(0.038)	0.331***	(0.026)
Rainfall Deviation from avg.	0.003***	(0.0003)	0.003***	(0.0003)	0.003***	(0.000)
Plot Characteristics						
Plot size (in Hectares)	-0.0003	(0.001)	-0.0003	(0.001)	-0.000	(0.001)
Soil Quality-Lem (v.good)	0.088***	(0.025)	0.087***	(0.025)	0.085***	(0.025)
Soil Quality-lem teuf (ok)	0.024	(0.027)	0.023	(0.027)	0.025	(0.027)
Plot slope (Flat=1)	-0.071	(0.053)	-0.072	(0.053)	-0.081	(0.057)
Plot Slope (sloping=1)	0.028	(0.055)	0.028	(0.054)	0.009	(0.059)
Observations	3,083		3,083		3,083	
R-squared	0.214		0.214		0.225	
chi2	549.7		546.4		539.0	
log likelihood	-1287		-1287		-1269	

Note: The dependent variable is a binary variable =1 if crop on plot is a cash crop; and 0 if it is a food crop
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Conditional Logit Model:

Table 8: Avg. Marginal Effects: Plot Crop Choices- Conditional Logit

		Basic		Food Share * Risk		Food Share * Markets
variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Household Characteristics						
Hh. Food Cons. (lagged)	-0.652***	(0.096)	-1.045***	(0.196)	-1.296***	(0.242)
Risk	0.154***	(0.059)	-0.336*	(0.195)	0.177***	(0.057)
Hh. Size	-0.001	(0.007)	-0.0001	(0.007)	-0.001	(0.006)
Male Headed hh. (=1)	-0.112***	(0.037)	-0.115***	(0.036)	-0.117***	(0.034)
Hh. Head Age	0.002	(0.001)	0.002*	(0.001)	0.001	(0.001)
hh. Number of crops	0.036***	(0.006)	0.037***	(0.006)	0.035***	(0.006)
Hh. Number of plots	-0.074***	(0.009)	-0.075***	(0.009)	-0.072***	(0.009)
Hh. Land in Hec. (Lagged)	-0.022	(0.044)	-0.020	(0.034)	-0.013	(0.021)
Education yrs: Adult Lit.	-0.056	(0.048)	-0.057	(0.049)	-0.056	(0.048)
Basic Education	0.002	(0.043)	0.007	(0.043)	0.009	(0.042)
Secondary Education	-0.057	(0.077)	-0.057	(0.078)	-0.086	(0.075)
Higher Edu.	0.047	(0.146)	0.0536	(0.132)	0.046	(0.144)
Mkt. & Community Factors						
Food Price Index (Lagged)	-0.442***	(0.124)	-0.198	(0.141)	-0.005	(0.172)
Distance to Town (in Km)	0.028***	(0.006)	0.033***	(0.006)	0.001	(0.012)
Better Roads (=1)	-0.084*	(0.048)	-0.090*	(0.049)	-0.304***	(0.017)
Distance to Mkt (in Km)	0.019***	(0.001)	0.022***	(0.006)	0.068***	(0.019)
Better Transport (=1)	0.521***	(0.086)	0.567***	(0.079)	0.382***	(0.017)
Rainfall Deviation from avg.	0.005***	(0.001)	0.005***	(0.001)	0.006***	(0.001)
Plot Characteristics						
Plot size (in Hectares)	-0.0003	(0.002)	-0.0003	(0.002)	-0.000	(0.002)
Soil Quality-Lem (v.good)	0.088**	(0.040)	0.099***	(0.038)	0.111***	(0.037)
Soil Quality-lem teuf (ok)	0.009	(0.041)	0.011	(0.041)	0.021	(0.040)
Plot slope (Flat=1)	-0.192***	(0.071)	-0.171**	(0.070)	-0.177**	(0.076)
Plot Slope (sloping=1)	-0.039	(0.074)	-0.0177	(0.074)	-0.032	(0.080)
Observations	6,166		6,166		6,166	
R-squared	0.415		0.417		0.427	
chi2	1015		1036		1059	
log likelihood	-1944		-1937		-1905	

Note: The dependent variable is a binary variable =1 if crop on plot is a cash crop; and 0 if it is a food crop
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

At plot level, in both the logit and conditional logit models, increase in household food consumption is associated with a decrease in the probability of selecting cash crops relative to food crops. The effect is larger in the conditional logit model where the average marginal effect of an increase in household food consumption is associated with a decrease in the probability of selecting cash crops relative to

food crops by 65.2% (compared to 31.5% in the logit model).
Overall, across specifications, the net effect of household food consumption is larger when difference in risk-preferences across households is considered through an interaction of both variables. This is in line with the results obtained in the household level analysis of crop choices. As such, the interpretation of the effect of food consumption on crop choices remains unchanged. All else equal, increase in household food consumption in the presence of market frictions such as transactions costs is likely to constrain households' ability to balance food demand through market exchange. Where these constraints are binding, farmers have incentives to internalize food markets through crop choices to maximize utility. Thus the decision to produce food crops rather than cash crops may result from the fact that gains from less reliance on markets to balance household food demand and hence achieve food security are higher than returns from producing cash crops. This difference is even larger when differences in risk preferences are accounted for as indicated in the second specification in which an interaction of food consumption and risk is added. The effect of risk-attitude through food consumption is likely to occur through farmers' concern for food security. Risk-averse farmers are likely to attach higher utility to food security and hence internalized food markets compared to risk-loving farmers. As a result, the effect of food consumption becomes more pronounced when risk is considered.

The effect of risk preferences on individual crop choices also follows a priori expectations. Risk loving farmers are more likely to select cash crops relative to food crops. The average marginal effects indicate that as farmers become more risk-loving, the probability of selecting cash crops relative to food crops increases by 15.4% on average (and 9.8% in the logit model). The net effect of risk on crop choices when interacted with food consumption is mixed. The logit model indicates that the probability of selecting cash crops increases by 9.5% (a slight decrease from 9.8% in the basic specification). The conditional logit model indicates that the probability of selecting cash crops decreases by 33.6% (from an increase of 15.4% in the basic specification). While it might difficult to reconcile these results, it indicates the sensitivity of the effect of food consumption on crop choices to risk preferences and vice-versa. An important result which has been documented in the literature is the role of risk on crop choices. In particular risk-aversion is gener-

ally associated with selecting low-return crops in several farming communities. As highlighted above, food crops considered in this chapter which are mostly cereals are generally low-risk due to their resistance to adverse climatic conditions. It is thus not surprising that where farmers are concerned about food security especially in the presence of yield and price risk and constraints on households' food demand, the selection of food instead of cash crops is constrained optimal.

As with the household level crop choices, the state of community infrastructure also influences crop choices. Farmers in communities with improvements in transport conditions are on average more likely to select cash crops relative to food crops. Although the size of the effect decreases when the difference in food consumption across households is accounted for, the effect is still statistically significant and positive. Farmers in communities with improved transportation are 38.2% more likely to select cash crops (or 33.1% from the logit model) after controlling for differences in the size of household food consumption. The effect of improvements in road conditions, distance to market and major town are individually smaller and contrary to expectations as found in the analysis of household level crop choices.

In summary, non-separability of farmers' production and consumption decisions is observed through the effect of household food consumption and risk preferences on crop choices- both selection of food and cash crops; and crop diversity. These effects are interpreted as indicators of the extent to which household consumption decisions are constrained by market conditions. In response, farmers internalize food markets through crop choices thereby establishing jointness between production and consumption decisions. The sources of frictions in markets which are likely to drive the link between crop choices and household consumption include transactions costs to market participation. The results indicate that community infrastructure relating to market access also has a significant effect on observed crop choices. The presence of these frictions breaks the substitutability of farm output and market goods and reinforces farmers' subjectivity towards own-farm harvest for household consumption. This creates incentives for farmers to produce food crops for household consumption thereby reducing reliance on markets to meet food demand. These gains which ultimately ensure household food security are potentially larger than returns from cash crop production or specialization

especially for risk-averse farmers facing price and yield risk without formal insurance.

2.4.3 Gains from Crop Diversification?

Using both household and plot-level crop choices to examine farmers' selection of food and cash crops and diversification of crop portfolio, it is observed that household food consumption and risk preferences significantly influence crop choices. This result shows the importance of crop choices for farming households especially when household decisions are non-separable. One interpretation of this finding is that farmers can internalize food markets by producing crops needed for household consumption to reduce reliance on markets in balancing household food demand. Thus farmers producing several crops are on average expected to be less constrained by frictions which affect household consumption. These farmers are expected to rely less on markets and more on own-farm harvest to achieve food security and higher consumption. This implication of our result can be tested by examining the effect of crop diversity on household consumption overtime. Using measures of crop diversity and household real consumption per capita from data collected in five waves of the ERHS (rounds 2 through 6) over a 10-year period we examine the effect of diversity on household consumption using Pooled OLS and Fixed Effects Estimators.
The results are reported below:

Table 9: Gains from Diversification

	Pooled OLS		**Fixed Effects**	
VARIABLES	log (r.cons)	log (r.cons)	log (r.cons)	log (r.cons)
Total crop diversity	0.325***		0.417***	
	(0.100)		(0.119)	
Food crop diversity		0.249***		0.360***
		(0.0850)		(0.0984)
rain deviation from avg.	-0.000135	-0.000156	-0.000114	-0.000150
	(0.000103)	(0.000103)	(0.000106)	(0.000104)
diversity*rain dev.	0.000304	0.000304	0.000230	0.000275
	(0.000304)	(0.000261)	(0.000321)	(0.000262)
Livestock Units (Lagged)	0.0150***	0.0147***	0.00865	0.00816
	(0.00432)	(0.00434)	(0.00665)	(0.00663)
land area (in hectares)	0.0220*	0.0210	0.0316*	0.0311*
	(0.0131)	(0.0131)	(0.0167)	(0.0167)
Constant	3.675***	3.652***	3.794***	3.787***
	(0.0565)	(0.0604)	(0.0440)	(0.0447)
Time Dummies	Yes	Yes	Yes	Yes
Location Dummies	Yes	Yes		
Hh. Fixed Effects			Yes	Yes
Observations	3,290	3,290	3,290	3,290
R-squared	0.230	0.229	0.062	0.062
Adj. R-squared	0.225	0.225	0.0592	0.0597
F	53.29	53.66	18.97	18.55

Note: The dependent variable is defined as log of household consumption per capita
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results indicate that, all else equal diversification of crop portfolio increases household consumption. In both measures of crop diversity (total diversity- production of food and cash crops; and food crop diversity- production of several food crops) and using both pooled OLS and fixed effects estimators, household consumption increases with crop diversity. Increase crop diversity through the production of food and cash crops is associated with an increase of 41.7% increase in household consumption on average. Whereas an increase in food crop diversity is associated with a 36% increase in consumption on average. Although the effects in the OLS model are smaller in magnitude, they are statistically significant. The joint effect of crop diversity and rainfall variation is small and statistically insignificant. The motivation for the interaction of crop diversity and rain deviation from average overtime is to capture the transitory nature of crop output on consumption as done by Paxson (1992). In the specifications without this interaction, the effects are generally larger but remain positive and statistically significant. It is also important to highlight the differences in the effects of crop diversity (defined

as a producing food and cash crops) and food crop diversity (defined as producing several food crops) on household consumption. The effect of the former appears to be larger in magnitude in both the pooled OLS and Fixed Effects estimated models. This perhaps illustrates the fact that by diversifying crop portfolio into food and cash crops, farmers are better able to minimize risk of consumption fluctuations. Although a combination of different food crops enables farmers internalize food markets, but this strategy might be limited by the lack of heterogeneity- the sensitivity of the individual crops to shocks such as pest invasion, rain variation etc. are likely to be correlated. On the other a portfolio comprising food and cash crops is likely to be less sensitive to shocks on one of the crop categories.

The positive effect of crop diversity on household consumption can be explained in several ways. In an environment where formal insurance is absent and frictions in output markets impose constraints on consumption decisions, diversifying crop portfolio constitutes an ex-ante coping strategy for idiosyncratic shocks (Dercon (2002)). Through crop diversity (supplemented by other strategies as reported by Dercon (1996)), farmers can be insured against consumption fluctuations due to yield and/or price risk. In a recent work, Mazunda et al. (2015) (Chap. 5 pp. 44-49) provide evidence of the effect of crop diversity on household consumption through food and nutrition security of farming households in Malawi. Hirvonen and Hoddinott (2016) also showed that crop diversity among Ethiopian farmers is associated with a significant increase in the nutritional diversity of children in households facing constraints in accessing food markets. These findings illustrate the non-separability of household production and consumption decisions through crop choices as strategies used to internalize food markets to ensure food security and facilitate household nutritional diversity.

In general, the results provide statistical evidence that through crop choices, farmers have incentives to internalize food markets. It appears, through the production of several crops, constraints on farmers' ability to balance household food consumption can be relaxed. Therefore, non-separability of household decisions among farming-households as indicated by the effect of household food consumption and risk attitude on crop choices can be interpreted as a constrained-optimal response to existing market conditions. In this chapter, we considered these effects

using different definitions of crop choices- selection between food and cash crops at household and plot level; and diversity of crop portfolio through the production of multiple food and cash crops.

2.5 Robustness Tests

The conditional logit model (also referred to as McFadden's Conditional Logit Model) offers a technique to incorporate individual and/or alternative fixed effects in modeling choices. This is considered as its improvement to other discrete choice models such as the alternative specific conditional logit model (which is a special case of the Conditional Logit model where fixed effects are ruled out). As a matter of fact, the conditional logit model can be estimated using the *asclogit* command in Stata since the post-estimation commands to obtain marginal effects for the *asclogit* are well developed- which is not the case for the *clogit* command. We followed this route (with the appropriate set-up of the data). However, concerns about the effect of unobserved time invariant crop and farmer attributes on crop choices still deserve proper attention. For this reason, a conditional logit estimation using the clogit command is necessary.

Despite these considerations, other concerns about the conditional logit model still remain. In particular, preference heterogeneity in repeated choices by individuals and the *Independence of Irrelevant Alternatives (IIA)* assumption are relevant in our analysis since farmers make multiple choices of crops on different plots. According to Train (2003), the IIA assumption implies that the stochastic component of a given alternative provides no information about the stochastic component of another alternative. However, violation of this assumption can be corrected by one of three options as discussed by Train: 1) use an alternative model that captures the correlation in the stochastic component of the alternatives. 2) Re-specify the error of each alternative to capture the correlated components leaving the uncorrelated component as white noise[19]. 3) Proceed with estimation of the model bearing in mind that the estimated model is at best an approximation of the representative utility function. (Train (2003)Ch. 3).
Although the conditional logit model is used in a context which is reasonable enough to argue that the IIA assumption is valid since the choice set is defined using grouped categories of crops- grains/food crops and cash crops. These categories of crops (as oppose to the individual crop choices which form these categories) are

[19]This can be facilitated by the Mixed Logit model as discussed in Train (2008) which can be estimated in Stata using the command *mixlogit* developed by Hole (2007) building on an earlier work by Haan and Uhlendorff (2006).

not expected to be significantly correlated as alternative choices. However, we attempted a re-estimation of crop choices using the Mixed Logit Model which considers these concerns with the Conditional Logit Model- See Hole (2007) for a discussion of this approach).

Therefore, while the conditional logit model incorporates fixed effects; the mixed logit model estimated using mixlogit is used to relax the IIA assumption and consider preference heterogeneity in choice models. On the basis of these concerns, we fit a mixlogit on the individual plot-level crop choices. The results are reported in the appendix. In general, the results do not seem to be very different from the results obtained from the conditional logit model.

2.6 Conclusion

Farming households make both production and consumption decisions. Production decisions serve as a direct source of food for household consumption (*producing what to eat*) and/or indirectly through market exchange of farm output with the returns used to meet other household needs (*producing to purchase what to eat*). The relationship between household decisions is often examined through the lens of existing market conditions. In environments where markets conditions are such that consumption decisions are constrained, farmers may choose to respond through production decisions thereby creating jointness/simultaneity in household decisions. This may occur through farmers' crop choices: the selection of food and cash crops; and crop diversity.

Frictions in the form of transactions costs and household subjective values towards own-farm output render markets imperfect by driving a wedge between market prices and endogenous household shadow prices. Differences in valuation between *'the market'* and *'the farmer'* lead to the breakdown of the perfect substitutability of farm output and market goods and family and hired labor. Where this frictions occur in food markets, farmers' face constraints on their ability to satisfy household consumption from farm profits. Through this relationship, farming decisions such as crop choices can be used to internalize food markets and reduce reliance on markets by producing food crops instead of cash crops to balance household food demand.

We test this hypothesis using household and plot-level crop choices of farmers in rural Ethiopia. We model farmers' choice between food and cash crops and the extent to which they diversify their crop portfolio as a function of household and market or community factors and plot-specific characteristics. We examine the extent to which observed crop choices reflect non-separability of household decisions through the effect of indicators of binding constraints on household food demand such as the size of household food demand, risk-attitude and market accessibility. We find statistical evidence that increase in household food consumption and risk aversion is associated with a decrease in the probability of selecting cash crops relative to food crops. For agricultural households, the effects of these house-

hold characteristics on crop choices can be interpreted as indicators of jointness of production and consumption decisions due to constrained consumption decisions. Through crop choices, farmers have incentives to produce food crops for household consumption thereby reducing reliance on markets to meet food demand. These gains which ultimately ensure household food security are potentially larger than returns from cash crop production or specialization especially for risk-averse farmers facing price and yield risk without formal insurance.

To further confirm whether non-separability of household decisions is reflected through crop choices as means of internalizing food markets, we examine the effect of crop diversity on household consumption overtime. Using five rounds of data on crop diversity and household consumption of the same farmers, we examine the size of gains from diversifying crop production by estimating a pooled OLS and Fixed Effects model. In both models, crop diversity is associated with increase in household consumption. Surprisingly, the effect of diversifying crop portfolio into food and cash crops has a larger effect on consumption than producing several food crops. This is perhaps because by producing both food and cash crops (rather than several food crops), risk of income loss due to poor harvest or price volatility is minimized thereby ensuring food security.

2.7 Appendix

2.7.1 Description of Variables

Table 10: Description of Variables

Variable	Description
Household Characteristics:	
Food Crop Only Farmer (=1)	A binary variable for farmers' of food crops only.
Index of crop diversity	An index of crop diversity measuring using the number of food & cash crops produced
Index of food crop diversity	An index of crop diversity measuring using the number of food crops produced
Hh. Food cons.	The proportion of household expenditure on food consumption.
Risk	A measure of household risk-attitude constructed using lotteries
Hh. Land in Hec.	Household land endowments in hectares.
Hh. Number of plots	Number of plots used by household
Hh. Size	Household size
Hh. Head Age	Age of household head
Male Headed hh. (=1)	Male headed household
Education yrs: No Schooling	Education level of household head= No Schooling
Education yrs: Adult Lit.	Education level of household head= Attended Adult Literacy program
Education yrs: Basic Educ.	Education level of household head= Basic/Primary Education
Education yrs:Secondary Educ.	Education level of household head= Secondary School.
Education yrs: Higher Educ.	Education level of household head= Higher Education-Post secondary
Community Infrastructure:	These were collected from eldrly members of a community such as Village head
Food Price Index (Lagged)	Food Price Index provided in ERHS
Better Transport (=1)	Improvement in access to other towns due to better transport systems
Better Roads (=1)	Improvement in access to other towns due to better road network
Distance to Mkt. (in Km)	Distance to market in kilometers
Distance to Major Town (in Km)	Distance to major town in kilometers- A measure of market/community integration
Rainfall Deviation from avg.	Constructed as annual community rainfall less 20 year average (from 1989).
Plot Characteristics:	
Plot size (in Hectares)	Plot size in hectares
Soil Quality-Lem (v.good)	Soil quality of plot- Lem is considered to be a very good quality
Soil Quality-teuf (good)	Soil quality of plot- teuf is considered to be a good quality, secondary to lem
Soil Quality-Lem-teuf (avg.)	Soil quality of plot- Lem-teuf is considered to be an average quality.
Plot slope (Flat=1)	Slop of plot- Flat
Plot Slope (sloping=1)	Slope of plot- sloping
multiple crop plot	Plot with several crops planted on
cash crop (=1)	Cash crop plot- coffee or enset
Food crop (=1)	Food crop plot- Teff, Barley, wheat etc.

2.7.2 Estimated Models

Table 11: Food Crop only Production vs. Food + Cash Crops: Logit Estimation

VARIABLES	(1) foodonly	(2) foodonly	(3) foodonly
Hh. Land in Hec. (Lagged)	0.115	0.117	0.0867
	(0.270)	(0.274)	(0.179)
Hh. Number of plots	0.0543	0.0514	0.0338
	(0.0510)	(0.0505)	(0.0486)
Risk	-1.067***	1.580	-1.009**
	(0.398)	(2.158)	(0.403)
Hh. Head Age	-0.0197**	-0.0196**	-0.0137*
	(0.00799)	(0.00798)	(0.00817)
Hh. Food cons. (lagged)	4.017***	6.150***	-8.804***
	(0.713)	(1.987)	(3.010)
Hh. Food cons.*risk		-3.319	
		(2.701)	
Better Transport (=1)	-4.787***	-4.832***	-21.47***
	(0.654)	(0.670)	(3.546)
Better Transport*Hh. Food cons.			19.49***
			(3.831)
Better Roads (=1)	-0.482	-0.477	12.79***
	(0.322)	(0.320)	(2.861)
Better Roads*Hh. Food cons.			-16.11***
			(3.312)
Distance to Mkt. (in Km)	-0.208***	-0.213***	-1.801***
	(0.0372)	(0.0382)	(0.307)
Distance to Mkt.* Hh. Food cons.			1.933***
			(0.348)
Distance to Town (in Km)	-0.321***	-0.326***	-1.129***
	(0.0609)	(0.0623)	(0.216)
Distance to Town*Hh. Food cons.			0.885***
			(0.218)
Food Price Index (Lagged)	8.974***	9.074***	9.812***
	(1.659)	(1.678)	(1.895)
Hh. Size	-0.0693	-0.0687	-0.0541
	(0.0431)	(0.0430)	(0.0452)
Male Headed hh. (=1)	0.646**	0.641**	0.586**
	(0.252)	(0.251)	(0.255)
Education yrs: Adult Lit.	0.277	0.298	0.422
	(0.286)	(0.287)	(0.309)
Basic Education	-0.193	-0.186	-0.0832
	(0.288)	(0.287)	(0.290)
Secondary Education	0.0404	0.0191	0.348
	(0.489)	(0.490)	(0.480)
Higher Edu.	-0.331	-0.286	-0.383
	(0.809)	(0.791)	(0.925)
Rainfall Deviation from avg.	-0.0281***	-0.0281***	-0.0360***
	(0.00598)	(0.00609)	(0.00571)
Constant	-4.361	-6.101**	6.316*
	(2.754)	(3.101)	(3.838)
Observations	781	781	781
R-squared	0.397	0.399	0.457
chi2	276.3	271.4	215.0

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 12: Tobit Estimation of: Diversity of Crop Portfolio

	Food & Cash Crop Diversity			Food Crop Diversity		
VARIABLES	diversityIndex	diversityIndex	diversityIndex	diversityIndex	diversityIndex	diversityIndex
Hh. Land in Hec. (Lagged)	-0.130	-0.135	-0.0306	0.326	0.334	0.266
	(0.447)	(0.448)	(0.395)	(0.341)	(0.343)	(0.317)
Hh. Number of plots	1.656***	1.658***	1.679***	2.939***	2.936***	2.914***
	(0.218)	(0.218)	(0.216)	(0.258)	(0.258)	(0.252)
Risk	2.306	-3.152	1.753	-4.100*	5.096	-3.640*
	(1.815)	(9.783)	(1.799)	(2.206)	(10.34)	(2.123)
Hh. Head Age	0.0298	0.0296	0.0168	-0.0976**	-0.0973**	-0.0857**
	(0.0331)	(0.0331)	(0.0337)	(0.0433)	(0.0433)	(0.0427)
Hh. Food Cons. (lagged)	-10.45***	-14.73*	13.43	13.14***	20.34**	25.05*
	(2.936)	(7.825)	(10.29)	(3.424)	(8.904)	(14.45)
Hh. Food Cons.*risk		6.855			-11.53	
		(11.82)			(12.58)	
Better Transport (=1)	12.08***	12.05***	26.91***	-23.45***	-23.41***	-31.99***
	(2.011)	(2.017)	(5.683)	(1.931)	(1.931)	(7.504)
Better Transport*Hh. food cons.			-17.76***			10.15
			(6.549)			(9.067)
Better Roads (=1)	5.858***	5.862***	0.812	10.55***	10.54***	29.26***
	(1.394)	(1.393)	(6.905)	(1.638)	(1.636)	(10.18)
Better Roads*Hh. food cons.			7.035			-23.52*
			(8.527)			(12.27)
Distance to Mkt. (in Km)	0.745***	0.751***	4.154***	-0.376**	-0.387**	-2.378**
	(0.193)	(0.193)	(1.092)	(0.189)	(0.191)	(1.110)
Distance to Mkt.* Hh. food cons.			-4.181***			2.492*
			(1.260)			(1.285)
Distance to Town (in Km)	0.630***	0.627***	1.508***	-1.911***	-1.905***	-1.479**
	(0.203)	(0.204)	(0.490)	(0.201)	(0.201)	(0.661)
Distance to Town*Hh. food cons.			-0.831*			-0.663
			(0.500)			(0.753)
Food Price Index (Lagged)	-2.123	-2.407	1.179	-22.77***	-22.31***	-25.35***
	(8.288)	(8.310)	(8.376)	(8.035)	(8.008)	(8.027)
Hh. Size	0.191	0.192	0.193	0.258	0.256	0.230
	(0.202)	(0.202)	(0.200)	(0.258)	(0.258)	(0.253)
Male Headed hh. (=1)	-0.132	-0.109	-0.126	4.849***	4.812***	4.814***
	(1.130)	(1.130)	(1.112)	(1.396)	(1.392)	(1.385)
Education yrs: Adult Lit.	-0.923	-0.936	-0.877	1.944	1.965	2.151
	(1.309)	(1.315)	(1.300)	(1.702)	(1.700)	(1.689)
Basic Education	-0.555	-0.571	-0.612	-2.505	-2.482	-2.617*
	(1.321)	(1.321)	(1.298)	(1.587)	(1.584)	(1.575)
Secondary Education	-1.374	-1.329	-1.489	0.309	0.241	0.702
	(2.861)	(2.843)	(2.847)	(3.538)	(3.546)	(3.491)
Higher Edu.	0.0367	-0.0639	0.519	3.497	3.652	3.423
	(4.154)	(4.217)	(4.109)	(10.05)	(9.927)	(9.999)
Rainfall Deviation from avg.	0.0542**	0.0535**	0.0819***	-0.261***	-0.259***	-0.273***
	(0.0231)	(0.0232)	(0.0254)	(0.0204)	(0.0203)	(0.0229)
Constant	6.888	10.70	-19.74	71.26***	64.86***	66.05***
	(12.85)	(14.55)	(16.68)	(11.89)	(13.31)	(17.57)
Observations	781	781	781	781	781	781
R-Squared	0.0361	0.0361	0.0394	0.0752	0.0753	0.0788
ll	-3042	-3041	-3031	-2997	-2997	-2943

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 13: Plot Crop Choices: Logit & Conditional Logit Estimation

	Logit Estimation			Conditional Logit Estimation		
VARIABLES	cashcrop	cashcrop	cashcrop	cashcrop	cashcrop	cashcrop
Hh. Size	0.0128	0.0130	0.0133	-0.00775	-0.000817	-0.00546
	(0.0248)	(0.0249)	(0.0246)	(0.0389)	(0.0384)	(0.0375)
Male Headed hh. (=1)	-0.523***	-0.518***	-0.510***	-0.644***	-0.662***	-0.679***
	(0.130)	(0.130)	(0.129)	(0.211)	(0.205)	(0.196)
Hh. Head Age	0.00965**	0.00974**	0.00808*	0.00999	0.0116*	0.00859
	(0.00451)	(0.00451)	(0.00461)	(0.00744)	(0.00704)	(0.00678)
Risk	0.720***	-0.340	0.687***	0.885***	-3.013**	1.024***
	(0.219)	(1.015)	(0.216)	(0.341)	(1.523)	(0.329)
Education yrs: Adult Lit.	-0.161	-0.163	-0.175	-0.328	-0.332	-0.327
	(0.198)	(0.199)	(0.202)	(0.287)	(0.294)	(0.289)
Basic Education	0.0491	0.0526	0.0491	0.00920	0.0402	0.0490
	(0.158)	(0.158)	(0.157)	(0.247)	(0.245)	(0.238)
Secondary Education	-0.231	-0.225	-0.324	-0.332	-0.330	-0.518
	(0.300)	(0.301)	(0.302)	(0.462)	(0.466)	(0.472)
Higher Edu.	0.308	0.314	0.298	0.267	0.303	0.261
	(0.551)	(0.545)	(0.564)	(0.823)	(0.747)	(0.818)
Food Price Index (Lagged)	1.919**	1.912**	2.162***	-2.534***	-1.137	-0.0286
	(0.894)	(0.894)	(0.838)	(0.714)	(0.809)	(0.997)
Hh. Food Cons. (lagged)	-2.324***	-3.207***	-1.087	-3.742***	-6.913***	-8.705***
	(0.362)	(0.965)	(1.693)	(0.561)	(1.444)	(1.784)
Hh. Food Share*risk		1.367			5.098***	
		(1.315)			(1.961)	
Better Transport (=1)	2.697***	2.701***	6.373***	2.992***	3.254***	6.689***
	(0.267)	(0.268)	(1.618)	(0.493)	(0.450)	(2.037)
Better Transport*Hh. food Cons.			-4.425**			-3.937*
			(1.850)			(2.286)
Better Roads (=1)	-0.381**	-0.387**	-4.944**	-0.483*	-0.519*	-7.749***
	(0.186)	(0.187)	(2.092)	(0.277)	(0.279)	(2.594)
Better Roads*Hh. food Cons.			5.585**			8.869***
			(2.487)			(3.106)
Distance to Mkt. (in Km)	0.122***	0.123***	0.573***	0.111***	0.127***	0.489***
	(0.0218)	(0.0221)	(0.130)	(0.0342)	(0.0340)	(0.147)
Distance to Mkt.* Hh. food Cons.			-0.564***			-0.456***
			(0.153)			(0.175)
Distance to Town (in Km)	0.174***	0.175***	0.224***	0.158***	0.189***	-0.0631
	(0.0254)	(0.0254)	(0.0831)	(0.0361)	(0.0369)	(0.0920)
Distance to Town*Hh. food Cons.			-0.0460			0.328***
			(0.0913)			(0.119)
Hh. Number of crops	0.157***	0.157***	0.147***	0.207***	0.214***	0.203***
	(0.0219)	(0.0220)	(0.0223)	(0.0338)	(0.0343)	(0.0334)
Hh. Number of plots	-0.280***	-0.280***	-0.263***	-0.426***	-0.431***	-0.417***
	(0.0336)	(0.0335)	(0.0327)	(0.0557)	(0.0537)	(0.0510)
Hh. Land in Hec. (Lagged)	-0.0521	-0.0526	-0.0386	-0.127	-0.115	-0.0764
	(0.0731)	(0.0732)	(0.0583)	(0.253)	(0.197)	(0.124)
Plot size (in Hectares)	-0.00212	-0.00219	-0.000665	-0.00159	-0.00170	-0.000192
	(0.00971)	(0.00974)	(0.00934)	(0.0101)	(0.0101)	(0.00959)
Soil Quality-Lem (v.good)	0.648***	0.642***	0.635***	0.505**	0.571***	0.641***
	(0.188)	(0.188)	(0.189)	(0.229)	(0.220)	(0.217)
Soil Quality-Lem-teuf (avg.)	0.178	0.167	0.191	0.0497	0.0625	0.122
	(0.200)	(0.200)	(0.202)	(0.236)	(0.234)	(0.230)
Plot slope (Flat=1)	-0.525	-0.527	-0.605	-1.102***	-0.982**	-1.025**
	(0.390)	(0.388)	(0.428)	(0.405)	(0.403)	(0.440)
Plot Slope (sloping=1)	0.210	0.205	0.0692	-0.225	-0.102	-0.186
	(0.404)	(0.402)	(0.443)	(0.424)	(0.423)	(0.461)
Rainfall Deviation from avg.	0.0239***	0.0237***	0.0259***	0.0284***	0.0300***	0.0333***
	(0.00253)	(0.00253)	(0.00266)	(0.00430)	(0.00391)	(0.00376)
Observations	3,083	3,083	3,083	6,166	6,166	6,166
R-squared	0.214	0.214	0.225	0.415	0.417	0.427

Table 14: Plot Crop Choices: Mixed Logit Estimation

VARIABLES	(1) Mean	(3) Mean	(7) Mean
Hh. Size	0.0119	0.0124	0.0130
	(0.0252)	(0.0252)	(0.0245)
Male Headed hh. (=1)	-0.538***	-0.534***	-0.519***
	(0.140)	(0.140)	(0.136)
Hh. Head Age	0.00997**	0.0100**	0.00825*
	(0.00469)	(0.00469)	(0.00454)
Risk	0.777***	-0.355	0.731***
	(0.229)	(1.175)	(0.222)
Years of Eduction	-0.00493	-0.00336	-0.0146
	(0.0706)	(0.0706)	(0.0686)
Food Price Index (Lagged)	2.054**	2.041**	2.215**
	(0.953)	(0.952)	(0.934)
Hh. Food Cons. (lagged)	-2.432***	-3.361***	-0.889
	(0.399)	(1.030)	(1.746)
Foodshare*risk		1.449	
		(1.478)	
Better Transport (=1)	3.025***	3.027***	6.514***
	(0.286)	(0.286)	(1.219)
Better Roads (=1)	-0.399**	-0.401**	-4.599***
	(0.192)	(0.192)	(1.189)
Distance to Mkt. (in Km)	0.136***	0.137***	0.603***
	(0.0284)	(0.0285)	(0.139)
Distance to Town (in Km)	0.192***	0.193***	0.233**
	(0.0285)	(0.0286)	(0.107)
Hh. food Cons.*Better Transport			-4.322***
			(1.420)
Hh. food Cons.*Better Roads			5.165***
			(1.426)
Hh. food Cons.*Distance to Mkt.			-0.590***
			(0.164)
Hh. food Cons.*Distance to Town			-0.0404
			(0.123)
Hh. Number of crops	0.175***	0.175***	0.161***
	(0.0248)	(0.0248)	(0.0238)
Hh. Number of plots	-0.310***	-0.310***	-0.287***
	(0.0361)	(0.0361)	(0.0349)
Hh. Land in Hec. (Lagged)	-0.0566*	-0.0573*	-0.0429
	(0.0313)	(0.0313)	(0.0307)
Plot size (in Hectares)	0.000326	0.000272	0.000966
	(0.0103)	(0.0103)	(0.0102)
Soil Quality-Lem (v.good)	0.657***	0.652***	0.646***
	(0.235)	(0.235)	(0.231)
Soil Quality-Lem-teuf (avg.)	0.159	0.150	0.175
	(0.247)	(0.247)	(0.243)
Plot slope (Flat=1)	-0.512	-0.515	-0.604
	(0.435)	(0.434)	(0.438)
Plot Slope (sloping=1)	0.192	0.187	0.0548
	(0.445)	(0.445)	(0.448)
Rainfall Deviation from avg.	0.0265***	0.0263***	0.0280***
	(0.00245)	(0.00245)	(0.00250)
cash crop	-7.286***	-6.541***	-8.628***
	(1.559)	(1.728)	(2.239)
Observations	6,166	6,166	6,166
chi2	15.79	15.60	8.749
ll	-1281	-1281	-1266

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3 Transactions Costs Effects on Farmers' Use of Farm Output: Market Exchange versus Household Consumption.

Abstract

We investigate transactions costs effects on farmers' market participation through their use of farm harvest for market exchange and household consumption. We test the hypothesis that the presence of transactions costs constrains market participation by lowering returns from market exchange of farm output thereby increasing gains from alternative uses of farm harvest such as household consumption. Previous studies have largely focused on the effects of transactions costs on market exchange. However, for farming households facing joint determination of production and consumption decisions, transactions costs are likely to also affect farmers' use of farm harvest for household consumption. The chapter makes a contribution in this regard. We also examine the heterogeneity of transactions costs effects across crop choices (categorized into cash and non-cash crops); and across farmers based on differences in diversity of crop portfolio. We test this hypothesis using 3 rounds of the Ethiopia Rural Household Survey (ERHS) data collected between 1999 and 2009. We find statistically significant effect of indicators of transactions costs on both farmers' marketing and consumption of farm output with the effect on the former being larger. In particular, distance to market lowers the volume of farm output sold and increases the proportion of household consumption obtained through farm harvest. On the other hand, improvements in roads and markets are associated with an increase volume of farm output used for market exchange; and a decrease in the amount use for household consumption. We interpret these results as the role of costly exchange of farm output due to transactions costs which create disincentives for farmers to participate in markets as sellers of farm output and possibly in making purchases for household consumption. Due to the relationship between production and consumption decisions for farming households, the use of farm harvest for household consumption under binding constraints on market participation, is constrained-optimal since it enables households internalize food markets.

Keywords: *transactions costs, market participation, farming-households, internalized markets, double-hurdle, Ethiopia.*
JEL Classification: D12 D13 O13 Q13

3.1 Introduction

In this chapter, we investigate the effect of transactions costs on farmers' allocation of farm output to market exchange; and the volume of household consumption satisfied through household production. Using plot-level data, the quantity of farm output sold in markets is obtained and aggregated across all crops produced on all plots owned by the household. Using rich consumption data, the contribution of home production to each item consumed (relative to other sources such as market purchases) is obtained. We combine this information on marketing and consumption of farm output with household and market/community characteristics relating to transactions costs to examine the extent to which costly market exchange influences farmers' decision to sell farm output or satisfy consumption through farm harvest.

Typically, studies in this area of research have focused on examining transactions costs effects on households' market participation as sellers or as buyers. However, given that subsistence farmers participate in markets as both sellers and buyers, we consider transactions costs effects on both uses of farm output to better illustrate the extent to which household market participation is constrained by transactions costs. The presence of transactions costs lowers incentives for market participation due to lower returns from market exchange or higher costs of meeting consumption decisions. For subsistence farmers, these two effects are linked through the household budget constraint- lower returns to farming constrain farmers' ability to finance household consumption decisions since crop income represents a large share of household income (see Dercon and Krishnan (1996)). This relationship also implies that subsistence farmers' have incentives to respond to these constraints by internalizing food markets through the production of crop(s) primarily for household consumption rather than market exchange. This reduces reliance on formal markets to meet household consumption- especially food demand; and hence non-participation or lower intensity of participation in markets. These responses establish jointness in household production and consumption decisions since choice of crops and diversity of crop portfolio are influenced by consumption preferences- see Singh et al. (1986d).

These relationships establish the foundation for studies on the extent to which farming decisions such as crop choices and allocation of farm output; are affected by market conditions. The hypotheses tested in these studies are formulated on the basis that farmers' choice of food crops over cash crops; and allocation of farm output for household consumption rather than market exchange are constrained-optimal responses to binding constraints on market participation due to frictions such as transactions costs.

We define market participation using farmers' allocation of farm harvest between market exchange and household consumption hence the jointness in household decisions. Other uses of farm output such as inputs for subsequent farming periods and barter with other households are not considered[20]. Through these definitions, we hypothesize that the presence of transactions costs reduces farmers' incentives to participate in markets as sellers farm output (due to lower net-returns from market exchange) or buyers of market goods (due to higher net costs of purchases). This occurs due to constraints on farmers' marketing of farm output and ability to balance household food demand due to transactions costs. We further hypothesize that in response to these constraints, alternative uses of farm harvest to market exchange such as household consumption are constrained-optimal. By internalizing food markets through the consumption of farm harvest, farmers reduce reliance on formal markets to maximize utility from consumption. This relationship between production and consumption decisions establishes jointness/non-separability in household decisions.

We test these hypotheses separately using farmers' decision to sell farm output (and the amount sold); and size of internalized food markets. This is defined using the contribution of farm harvest to the quantity consumed of a given item relative to other sources such as quantity of purchased goods. This is done for all items consumed by a household in a given period and aggregated to household level. In addition, we extend this framework to examine the heterogeneity of transactions costs effects across farmers based on differences in crop choices (cash crop

[20]These uses are likely to be very small as indicated by the size of the contribution of gifts and other exchange of goods between households to total household consumption. The descriptive statistics indicate that, on average, 71% of items consumed by households surveyed is market purchased, 26% is household produced and 3% is obtained from other households (exchanges, gifts etc.).

versus non-cash crop) and diversity of crop portfolio. The role of differences in crop choices and diversity is motivated by the fact that farm output from food crops such as cereals is mainly used for household consumption (although a small percentage may be used for market exchange to finance other household needs). Cash crops such as coffee on the other hand are predominantly produced for market exchange. As a result, differences in farmers' choice of crop and composition of crop portfolio are likely to create a heterogeneous effect of transactions costs on market participation such that cash crop producers (whether produced with other food crops or not) are less constrained by transactions costs.

The data used in the analysis is obtained from 3 rounds of the Ethiopia Rural Household Survey (ERHS) collected between 1999 and 2009. We construct a panel data of farmers' marketing of farm output and use for household consumption along with indicators of transactions costs, farmers' choice of crop (cash crop versus non-cash crops) and a measure of crop diversity. Farmers' market participation decision is defined as a two stage process defined and examined separately for both selling and consuming farm output. In the first stage, farmers make a discrete choice of participating or not (i.e. to sell or not; and consume farm output or not). The second stage represents the continuous choice of scale of participation (i.e. the quantity of farm output to sell and consume). This approach is widely used in the literature to capture the possibility of a differential effect of transactions costs on the two stages of farmers' market participation decision. Empirically, we estimate transactions costs effects on market participation as defined above using Cragg's double hurdle model (which accommodates corner solutions as optimal responses to binding constraints on marketing decisions). The first hurdle represents the discrete choice and second hurdle represents the continuous choice. Other concerns such as unobservable household heterogeneity is controlled for by augmenting the double hurdle model with Correlated Random Effects implemented by adding time-averaged household characteristics.

We find statistical evidence that distance to market and major town lowers both farmers' probability of participating as sellers and conditional on participation the volume of farm output sold. Distance to market is assumed to reflect the size of explicit marketing costs such as transportations costs; and implicit costs such as

opportunity costs of time spent selling farm output. Distance to major town on the other hand, is assumed to indicate the extent of market integration and access to larger markets with bigger clientèle. Improvements in road conditions and markets appear to have a larger effect on farmers' intensity of participation. Sellers of farm output in communities with such improvements and hence lower transactions costs appear to participate more intensely on average. These results illustrate the effect of costly exchange as constraints on farmers' marketing of farm output- especially non-cash crop farmers and farmers with less diverse crop portfolio whose discrete choice to participate appears to be constrained by distance to market.

The use of farm harvest for household consumption also appears to be influenced by transactions costs. Similar to marketing of farm output, the effect of distance to market is much smaller. However, improvements in road conditions and markets significantly lower the use of farm harvest for household consumption. In general, we interpret these results as the role of costly exchange of farm output due to transactions costs which create disincentives for farmers to participate in markets as sellers of farm output and possibly in making purchases for household consumption. Due to the involvement of farming households in both production and consumption activities, responses to these constraints can occur through the increased use of farm harvest for household consumption and decreasing the volume of farm output used for market exchange.

3.2 Literature Review

For farming households, market participation involves the sale of farm output and the purchase of goods for household consumption. The relationship between these two is established through household budget constrain since returns from market exchange are used to finance consumption decisions. Alternatively, where farmers are involved in the production of food crops, farm output can be used for market exchange or household consumption. Farmers' choice between these two strategies has been examined in the context of existing market conditions. In particular, the production of food crops and use of farm output for household consumption may be driven by differences in utility derived from market and household produced goods for consumption decisions; or differences in market and shadow prices for sale of farm output.

What drives these differences in utility or prices? Growing empirical evidence points towards costly exchange such as transactions costs to market participation. The presence of transactions costs distorts market prices and utility farmers derive from consuming market goods. This lowers incentives to participate in markets as sellers of farm output and buyers of goods for household consumption. The effect on marketing of farm output occurs through lower returns net of transactions costs which constrain market participation and farmers' ability to finance consumption decisions. Similarly, the presence of transactions costs in food markets increases market prices relative to farmers' valuation thereby constraining farmers' ability to balance household food demand. Farmers' response to these constraints can be examined through crop choices, participation and intensity of participation in markets. Farmers likely to be constrained by transactions costs have incentives to produce food crops ex-ante primarily for household consumption rather than cash crops for market exchange. By internalizing food markets, the constraints on consumption decisions are relaxed since farmers reduce reliance on markets to meet household consumption decisions. Similarly, these constraints can be relaxed by using farm output for household consumption rather than market exchange resulting in non-participation or low intensity conditional on participation in output markets. These responses have been cited as explanations for the weak response to agricultural policy targeting increased market participation of farmers imple-

mented through exogenous price increases reported by several studies.

The heterogeneity in the extent to which constraints due to transactions costs are binding on farmers' market participation in a given community can be examined through differences in choice of crops and farmers' ability to internalize food markets among others. Farmers producing cash crops such as coffee are expected to be more market oriented and less likely to be constrained by transactions costs compared to non-cash crop producers. We consider this extension in the chapter.

The chapter draws from contributions by several studies on market participation of farming households. A selected review is discussed in the following sections highlighting the state of the literature and the contributions this chapter attempts to make.

3.2.1 Price Changes, Market Participation & Transactions Costs

Price increases for agricultural produce have been a common policy targeting increased agricultural commercialization in the developing world. It is hypothesized that such interventions would create incentives for farmers to expand production of cash/export crops (relative to subsistence crops), increase intensity of market participation (i.e. increased quantity of farm output sold), and food security (through higher returns from farming) *ceteris paribus*. Several papers have attempted to test this hypothesis by examining farmers' response to changes in market prices- the price elasticity of marketed surplus (total farm output net of household consumption of farm output) such as Strauss (1984b) and several other studies reviewed in Singh et al. (1986d). Extensions of these papers incorporated other dimensions such as the role of household inventory (Renkow (1990)); and household risk (Finkelshtain and Chalfant (1991)). Contrary to expectations, several studies reported weak (in some cases negative) price elasticity of marketed surplus.

A common explanation for this result is built around the assumption about the state of markets. The construct of the hypothesis that price increases create an incentive strong enough to influence farmers' marketing of farm output is set of the belief that markets are perfect. This assumption implies that prevailing mar-

ket prices reflect farmers' valuation of farm output such that market prices equate farmers' shadow prices. As a result of the equality of prices, market and similar household produced goods (through farming activities) are perfect substitutes to the household making consumption decisions. Under these conditions, farmers' production and consumption decisions can be examined separately (akin to a firm-household structure) for the purposes of an empirical study. The separability of household decisions implies that farmers choose production decisions to maximize farm profits; which are then used to finance consumption decisions chosen to maximize utility (Singh et al. (1986d)).

Under this theory of farming households, differences in expected and observed responses to price changes can be attributed to market conditions. The presences of market frictions such as transactions costs in market exchange create inequality between market and shadow prices of farm output. This establishes jointness in household production and consumption decisions. The simultaneity in household decisions stems from endogeniety in the budget constraint due to shadow prices which constraints households' ability to satisfy consumption decisions from returns to selling farm output. Where this constraint is binding, alternative strategies to market participation such as production of subsistence crops for household consumption rather than cash crops for market exchange; and/or limiting market participation by consuming a greater share of own-farm output maybe considered by farmers. These considerations are formally incorporated into what is often referred to as models of agricultural households (See Singh et al. (1986d)) and used in several empirical studies on the behavior of farming households.

3.2.2 Transactions Costs and Market Participation

In light of these concerns, attempts have been made to identify market conditions which drive a wedge between market and shadow prices of farm output and market goods. A particularly popular explanation for the differences in prices is built around the theory of costly exchange due to Coase (1937) in which he discussed that economic transactions do not occur in frictionless environments. This argument has been extended to market participation of farmers in which transactions are defined as market exchange of farm output and purchase of market goods for household consumption. The frictions highlighted by Coase (1937) occur when

markets are characterized with "...pecuniary and non-pecuniary costs associated with arranging and carrying out an exchange of goods and services" as defined by Holloway et al. (2000) p.280 thereby constraining market participation decisions. Thus they broadly relate to various forms of costs associated with market exchange such as search, negotiation, monitoring and enforcement of agreements, cost of transportation among others hence the term transactions costs. In the marketing of farm output which has attracted a lot of attention in the literature, farmers also face costs due to risk of spoilage and uncertainties about marketing outlets and price changes Sadoulet and De Janvry (1995b), Staal et al. (1997) among others.

In developing countries, these costs are driven by the state of rural infrastructure such as road networks, access to information, support services among others; and household characteristics such as access to information, means of transport, experience etc. Farmers in communities with poor infrastructure, face isolated and thin markets, risk wastage of farm output and price volatility. These conditions result in high participation costs thereby constraining farmers' decision to participate in markets (Staal et al. (1997))[21]. The link between transactions costs and market participation is such that under high transactions costs, "...transactions simply do not occur, or substitute institutions emerge to allow the transactions to take place" leading to *missing markets* De Janvry et al. (1991b). This results from the fact that high transactions costs create disutility greater than the utility created from market exchange such that a corner solution of non-participation can be optimal. This observation has been widely accepted as an explanation for the weak response to exogenous price increases due to policy interventions aimed at creating incentives to increase the scale of agricultural commercialization (see Weber et al. (1988)).

Analytically, transactions costs are incorporated into farmers' market participation decisions as constraints in the form of price boundaries with shadow prices as benchmarks. Where market prices net of (or adjusted for) transactions costs are

[21]Osborne (2005) examined competitiveness of markets in Ethiopia and fails to find statistical evidence to support perfect competition in Yetem (low trade volume and distant market) but inconclusive evidence against imperfect competition for Debre Zeit (high trade volume and nearer to capital city).

too low (or too high for purchasing decisions) relative to shadow prices, farmers may find it optimal to opt out of participating in markets. This, as discussed in Minot et al. (1999), explains the low price elasticity of marketed surplus (defined as farm harvest less household consumption) found in earlier empirical studies and thus the need to consider the market participation costs in the formulation of agricultural policy as highlighted in Braun et al. (1994).

Similarly, in a widely cited paper in the transactions costs effects literature, Goetz (1992b) illustrated the differential effects of price interventions on autarkic, sellers and buyers under costly market participation such as the presence of transactions costs in both selling and buying decisions. Under these conditions, government intervention to increase market prices is likely to benefit households who are net-sellers in markets since returns from market exchange of farm output is likely to be higher than costs of purchases. Net-buyers on the other hand, are likely to lose from such interventions since price inflation of purchases may outweigh gains from sales. Non-participating or autarkic households may not gain from such interventions. Similar concerns are also raised in Braun et al. (1994) and Omamo (1998b). However, examining transactions costs effects on farmers' discrete market participation decision (i.e. to participate or not) maybe restrictive. Heterogeneity in transactions costs effects may result in not only different outcomes for market participants and non-participants but also among participants. To capture this, the marketing of farm output decisions can be defined to follow a two-stage process- a discrete choice of participation versus non-participation; and a continuous choice of intensity/volume of participation[22].

In an influential paper on market participation decisions of agricultural households, Goetz (1992b) examined strategic factors which influence buying and selling decisions of coarse grain producing farmers in Senegal. Using a two-step estimation process, he examined farmers' decision to participate and intensity of their participation. In the first stage, the probability that a given household will choose to participate as a buyer/seller is examined as a function of household characteristics

[22]The extent to which discrete and continuous marking decisions are sequentially or simultaneously determined has also attracted some interest. A recent study was done by Bellemare and Barrett (2006). They reported statistical evidence of sequential determination of marking decisions using data from farmers in Kenya and Ethiopia.

and estimated using a probit model. In the second stage, a switching regression model is estimated for buyers and sellers in which households select themselves into buying and/or selling. Contrary to expectations, he found that higher prices were associated with higher likelihood of households participating as buyers. This he attributed to the possibility that increased prices may signal a likelihood of food scarcity encouraging farmers to increase their inventory of grains. Other factors such as access to technology reduces households likelihood of participating as buyers but larger household size increases it; better market information influences households participation decision as sellers; access to means of transport (cart) decreases chances of participating as buyer unless it is accompanied with better information. The opposite is found for sellers.
In terms of volume of participation, scarcity of rice intensifies buyer participation in grain markets. Conditional on participation, the intensity of participation (which is measured by the volume of purchases and sales of buyers and sellers respectively) increases with improved access to production enhancing technology. Increased household size influences quantity transacted by buyers; while higher dependency ration increases the quantity sold.

The link between link between market conditions and household characteristics in farmers' market participation decisions as reported by Goetz (1992b) raised interest in examining the role of transactions costs on agricultural commercialization. This has been done by identifying indicators of transactions costs and measuring its effects- i.e. the extent to which costly exchange drives heterogeneity in households' marketing decisions- participation versus non-participation; and low or high intensity conditional on participation.

3.2.3 Identifying Transactions Costs Effects on Market Participation.

The identification of transactions costs involves obtaining measures of market accessibility such as distance to market and state of infrastructure, availability of public goods such as agricultural support services; and household characteristics which influence or ease market participation (Sadoulet and De Janvry (1995b)). To examine the effect of these measures on the two-stage market participation decision framework proposed by Goetz (1992b), Key et al. (2000) proposed differentiating transactions costs into: Proportional Transaction costs (PTCs) and

Fixed Transaction costs (FTCs). PTCs are dependent on quantity bought or sold such as transportation costs; FTCs on the other hand are independent of quantity such as search and bargaining costs.

Although this distinction provides conceptual foundation for examining the role of transaction costs, empirical identification is rather challenging since measures of transactions costs can only be obtained when transactions occur-i.e. farming-households participates as a seller of farm output or buyer of market goods. The effect of transactions costs on non-participants is empirically challenging. With these limitations, several studies on market participation attempted to estimate the extent to which the indicators of transactions costs highlighted above drive the differences in observed marketing decisions- participants and non-participants; and differences in the intensity of participation among participants. A typical application is presented in Goetz (1992b) by including indicators of transaction costs in marketed surplus equations to back its effect on participation decisions[23]. To separately identify and estimate proportional and fixed transaction costs is even more challenging. However, Key et al. (2000) proposed a censored regression threshold in their work on market participation and supply decisions of corn farmers in Mexico.

In another application, Vakis et al. (2003) argued that in an environment where farmers face multiple markets, observed choice of market can be used to examine the extent to which transactions costs affect market participation. They reported that fixed transactions costs are quite large for potato farmers in Peru and potentially affected by information sharing among co-villagers. Hence, lower transactions costs effects for potato farmers can be achieved with improvements in information about markets. However, the authors did not examine the size of the effect of transactions costs relative to producers of other crops in the community. Barrett (2008) proposed a parametric approach to estimating transactions costs for cereal farmers in Eastern and Southern Africa. In his work, market prices are adjusted for household, crop and location specific indicators of transaction costs (such as public goods, households characteristics that influence negotiation skills, household liquidity etc.).

[23]Similar approach was used to examine the effect of transaction costs on land rental- Skoufias (1995) and labor market imperfections-Sadoulet et al. (1998).

Indicators of transactions costs apart from distance to markets and household attributes such as community characteristics have also been considered to pin down heterogeneity in transactions costs effects on market participation across space. To motivate this, Renkow et al. (2004) in an attempt to quantify fixed transaction costs and its effect on demand and supply decisions of maize growing households in Kenya using a maximum likelihood approach reported that fixed transaction costs are estimated to be around a price band of 15.5% around the market price. Allowing for transactions costs differentials across villages, they found that: villages served by truck have a fixed transaction cost of about 11% while those served by animals or bicycle have fixed transaction costs of the magnitude of 15%. The effect of distance is significant for villages served by trucks but insignificant for villages with bicycles or animals as means of transport.

These results provide empirical evidence that differences in market participation is sensitive to differences in the state of markets across communities. In particular, the competitiveness of markets, access to extension/support services, quality of roads, geographic factors such as connectedness or proximity to major town(s) appear to influence market participation. These effects operate by constraining access to information, spatial transmission of prices and incentives for arbitrage. Barrett (2008) considers these factors by defining transactions costs in terms of access to markets, integration of local markets with global markets, trader competition, fiscal policies that affected road networks, security, exchange rate devaluation that increased cost of tradables such as fuel, price risk etc.

Disintegration of markets over space due to high transportation costs and differences in agricultural productivity as highlighted in Fafchamps (1992) are likely to drive volatility in prices. In his simulated model with three hypothetical households- fully commercialized, partially commercialized and mostly self-sufficient household, he argued that to create incentives for cash crop production, policies to integrate food markets and/or fix food crop prices need to be implemented. Such policies will facilitate cash crop production by reducing food price variance, covariance between individual output and total supply, a more elastic supply (due to substitution possibilities in more integrated markets) and ultimately less re-

liance on self-sufficiency. This is expected to reduce farmers' desire to internalize food markets and thus expand scale of agricultural commercialization by producing cash crops.

Other than community infrastructure, differences in agronomic factors across villages introduce variation in agricultural productivity thereby affecting market participation of farmers within the community and the size of markets across communities. The differences in climatic and related conditions across communities affects the number of possible crop choices and hence the size of markets within the community. Communities with bigger crop choice sets by virtue of their agronomic characteristics, are likely to attract a large number of buyers from neighboring communities thereby increasing the size of markets. Furthermore, where markets are less integrated or connected, the transmission of prices and access to information is constrained thereby affecting gains from market participation. Earlier studies on market integration relied on correlation between prices of pairs of markets. Later studies examined correlation of price differences between pairs of markets. Recent studies using spatial price transmission have used co-integration techniques of prices in different markets to examine market integration. Badiane and Shively (1998) examined the role of spatial market integration on price changes and transmission between local (main market of a net importing region) and central (main market of a net exporting region) markets controlling for the effect of transportation costs of the speed of adjustment/convergence of prices across maize markets in Ghana. They reported that the extent of integration between the two local markets and a central market differ in part due to differences in distance and level of market infrastructure creating differences in price transmission. On average, it takes 4 months to achieve complete adjustment of prices across prices.

The nature of price transmissions according to Abdulai (2000) may not by symmetric as assumed in most of the earlier papers (i.e. following a shock to central market prices, local market prices follow similar (symmetric) response and that the tendency to move towards long run equilibrium is always present). Differences in market imperfections in the form of government intervention, positive inventory, collisions by middlemen etc. overtime may affect the nature of the linkage across markets at various time periods. Such relationships are better captured by

threshold models of dynamic equilibrium. He failed to find statistical evidence to support the existence of symmetric price adjustments in maize markets in Ghana. Getnet (2008) also reports weak transmission of grain prices in Ethiopia. Although it appears that the duration for complete adjustment of prices is long providing opportunities for arbitrage, the existence of transportation costs due to distance between markets overshadows possible gains from arbitrage.

Other forms of community infrastructure such as group marketing associations, agricultural cooperatives and extension services have been considered. The availability of these agricultural support institutions are expected to influence market participation decisions by lowering search costs and information asymmetry about markets. Staal et al. (1997), Holloway et al. (2000) among other studies have considered these factors.

3.2.4 Responding to Transactions Costs Effects

The resulting jointness in household decisions under binding constraints on market participation due to transactions costs can be examined through the extent to which the link between production, consumption marketing and storage of farm output decisions ais influenced by indicators of transactions costs. See Park (2006) for a comprehensive discussion of these inter-linkages. This relationship stems largely from the fact that under binding constraints on market participation, farmers' ability to balance household food demand is affected. As a result, agricultural decisions of subsistence farmers are likely to be sensitive to food security concerns where transactions costs result in uncertainties about markets and price risk/volatility (as discussed in Ellis (1993)). Thus, in addition to non-participation in markets, farmers may find it optimal to internalize food markets through ex-ante and ex-poste production decisions. Conceptually, this response follows directly from the creation of substitute institutions to formal markets which are *missing* due to high transactions costs discussed by De Janvry et al. (1991b).

Several of these faming decisions have been examined in the literature. On crop choices, Jayne (1994) and Omamo (1998b) examined the effect of marketing costs (such as distance to market) on farmers' likelihood of producing cash crops. Similarly, Fafchamps (1992) examined food price volatility, rural market integration

and crop choices. Other decisions such as choice of market have also been studied by Hobbs (1997) and Fafchamps and Hill (2005) among others.

Renkow (1990) (one of the earlier papers exploring heterogeneous effects of transactions costs) examined the relationship between household farm output inventory and marketed surplus of small-scale and large-scale (defined by farm size) farmers in India. In particular, the study examined the extent to which differences in the intensity of market participation (and the need to keep positive inventory of farm output) between large-scale and small-scale farmers can be attributed to differences in transactions costs effects and anticipated gains from arbitrage. Although larger production capacity of large-scale farmers create incentives for arbitrage and positive inventory (since they face lower average transactions costs), food security concerns of small-scale farmers did not significantly influence storage demand. The author explains this result as the role of government funded food for work projects received by small-scale farmers.

The work of Renkow (1990) had a couple of limitations as identified in later work: specification of storage costs across time periods, the definition of food security in the inventory demand function depended on a specific functional form of the storage cost and assumption of risk neutrality[24]. Saha and Stroud (1994) used quarterly panel data of farmers marketing of farm output from Shirapur-India to account for these shortcomings. They reported that risk responses of households differ by farm size and food security may not be the only motive behind farmers' decision to hold positive inventory; arbitrage (or convenience yield as referred to in the literature) may explain part of such behavior. However, food security appears to be an important motivation for deficit farmers to hold positive storage of farm output during times when speculative motive was absent. Getnet (2008) report similar findings for grain farmers in Ethiopia. Farmers lack formal mechanisms to absorb price risks except to abandon or reduce improved production technology[25].

[24]Binswanger and Sillers (1983) discuss how differences in household's attitude towards income risk affect farming decisions.

[25]Benirschka and Binkley (1995) offer a different approach by building on the theory of optimal resource extraction. The alternative approach- the theory of efficient commodity markets, argues that differences between spot prices and futures prices should equate storage and insurance costs. However, empirical evidence has found otherwise- the gap between the two prices is usually less than storage costs. They examined storage decisions across producing regions and marketing decisions over time using US data.

On choice of farming technology and marketing of farm output, Alene et al. (2008) examined transactions costs effects on Kenyan farmers' demand for fertilizer and supply of maize by estimating demand and output supply functions. They reported that marketing decisions are significantly influenced by access to technology facilitated by access credit and support services such as extension works. Jointly, these factors are expected to relax transactions costs constraints by facilitating expansion in scales of production and improve access to information about markets and production techniques. In terms of use of fertilizer, they reported that access to means of transport increases fertilizer use while distance to fertilizer market has the opposite effect, all else equal.

Aside from responses to constraints due to transactions costs through production decisions ex-ante, such constraints can be relaxed through ex-poste responses such as farmers' allocation of farm output to household consumption. Much of the empirical literature in this area of research has focused on examining transactions costs effects through marketing of farm output. However, due to the jointness in household decisions, the presence of transactions costs is likely to affect both the marketing of farm output and use of farm output for household consumption. The former is likely to be driven by lower net-returns whereas the latter may constitute a substitute institution to missing food markets (ala De Janvry et al. (1991b)) since it enables households reduce reliance on markets for household consumption.

These studies provide statistical evidence that the link between farming decisions such as choice of crops and production technology and transactions costs occurs through constraints on market participation which establish jointness of household decisions. The effect on market participation occurs through costly exchange of farm output and purchase of goods for household consumption due to transactions costs. Through various contributions in the literature, these costs can be identified from the state of community infrastructure which indicate market accessibility- distance to and integration of markets, access to information about market prices etc; and household characteristics such as experience in farming, search and bargaining skills, information processing skills among others.

Several studies have examined transactions costs effects on marketing of farm

output through farmers' decision to sell farm output and the quantity sold by sellers of a given crop. Rather than focusing on market participation at individual crop level, we extend this framework to incorporate multi-crop farming by defining market participation at household level through the aggregate of output of all crops produced by farmers in a given farming period. Marketed surplus of each crop defined as the proportion of farm output a given crop sold is obtained for each crop produced by a farmer. An index of intensity of market participation is constructed at household level using these measures and used as our definition of market participation. In addition, we also examine role of differences in crop choices and diversity of crop portfolio on the extent to which constraints on market participation due to transactions costs are binding. We expect these differences to be influenced by differences in market orientation between cash and non-cash crop producers and size of internalized food markets through crop diversity to minimize the impact of transactions costs effects on farmers' ability to meet consumption decisions[26].

The main contribution however is in the analysis of transactions costs effects on farmers' use of household produced goods for household consumption. We hypothesize the size of household consumption basket satisfied through self-produced goods reflects the extent to which market participation is constrained by transactions costs. Previous studies have largely focused on the effect of transactions costs on marketing of farm output. While this provides an indirect indication of the extent to which transactions costs may constrain consumption decisions due to lower returns to market exchange, a direct effect can be obtained through the analysis of transactions costs on farmers' use of farm output for household consumption. By combining the analysis of transactions costs effects on marketing of farm output and use of household produced goods for household consumption, we can obtain a better insight into the effect of transactions costs on farming-household decisions and the differential effect of transactions costs on marketing and consumption decisions.

The data from three rounds of the ERHS is used to construct a rich balanced

[26]Other studies have considered the role of sharecropping and interlocking of factor markets as responses to imperfect markets. See Bardhan (1980), Braverman and Stiglitz (1982) among others.

panel at household level. This enables us to deal with the problem of unobserved heterogeneity typical in studies using cross-sectional data. Each round of data contains information about households' marketing of farm output, use of farm output for household consumption, household characteristics such as household wealth, ownership of a means of transport, number of plots and information about household head among others. Community characteristics such as distance to market and major town, road conditions, food prices, availability of agricultural support services are also obtained. We combine this information to examine the effect to which transactions costs constrain market participation and the heterogeneity of such effects. Using the same framework, we also examine transactions costs effects on farmers' use of household produced goods for consumption.

3.3 Methodology

3.3.1 Conceptual Framework

Before outlining the theoretical and empirical models and the data used for the analysis, a description of the setting we examine with a summary of household activities is presented below.

- The production side of the household consist of activities relating to rain fed farming and similar agricultural activities- the production of food and/or cash crops. Output from a given farming season is mainly used for household consumption and market exchange. Other uses of farm output include as inputs for subsequent farming periods and as gifts and barter with other households. We do not consider these other uses in our analysis.

- Household consumption decisions are satisfied through market purchases and/or use of farm harvest. The volume of market purchases and consumption of farm harvest expressed as a proportion of the total quantity of each item consumed by the household in a given period of time is obtained. Other sources such as barter and gifts represent a small proportion and are not considered in the analysis.

- Households participate in markets as sellers of farm output and buyers of goods for household consumption. Some of the goods purchased are also produced by the households. The substitutability of market and household produced goods and hence the intensity of market participation is expected to be sensitive to the presence of transactions costs. Under binding constraints on market participation, household responses include non-participation, low intensity of participation or internalizing food markets through the use of household produced goods for household consumption. Other factors which are likely to affect this relationship include exposure to risk due to uncertainties about rain and price volatility resulting from thin and less integrated markets.

- Based on this relationship, we examine the effects of transactions costs and household risk preferences on household market participation defined above. Transactions costs are indicated by the state of community infrastructure (dis-

tance to market, distance to major towns, and road conditions) and household characteristics such as levels of education, ownership of means of transport, production capacity etc; whereas risk preferences are elicited from household choices in lotteries with monetary payoffs constituting cash and market price of farm output.

- We also examine the heterogeneity of transactions costs effects on farmers based on differences in crop choices (cash versus non-cash crop farmers) and diversity of crop portfolio.

3.3.2 Theoretical Model

Following Barrett (2008), we describe household decisions as follows below. We begin with an illustration of the notation used:
Household Consumption:

- Households consume goods indexed by $\jmath$ in a given time period - $c_\jmath$ where $\jmath = 1, 2, \ldots J$. This goods are obtained from:
- Household/self produced goods- $c_\jmath^h$; and
- Market purchased goods-$c_\jmath^m$

For compactness, let $\mathbf{c}$ be a vector of all goods consumed by households.
Household Production:

- Households produce $q_\jmath$ quantities of good $\jmath$ in a given time period; using q_x quantity of inputs which are either market purchased-q_x^m; or household produced-q_x^h such as saved seeds.
- Household produced goods are for consumption-$c_\jmath^h$; sold at market prices-$q_\jmath^m$;

For compactness, let $\mathbf{q}$ be a be a vector of production related variables where output enter with positive values ($q_\jmath > 0$) and inputs with negative values ($q_x < 0$).
To describe transactions costs effects on household decisions, we begin with a

benchmark model which illustrates household behavior in the absence of transactions costs. This is followed by a definition of transactions costs with which we augment the benchmark model to illustrate transactions costs effects on farmers' allocation of farm output.

In the absence of transactions costs, the utility maximization problem of a representative farming-household is presented below[27]:

$$\max_{\mathbf{c},\mathbf{q}} \; U\left(\mathbf{c},;Z_i^c\right) \tag{25}$$

where Z_i^c- demand shifters of household i.
The utility maximization is subject to the following constraints:

$$\left[\left(\sum_{j=1}^{J}\left(p_j\left(c_j^h+c_j^m\right)\right)\right)+\left(\sum_{x=1}^{X}\left(p_x\left(q_x^h+q_x^m\right)\right)\right)\right]\leq\left[\sum_{j=1}^{J}\left(p_j.q_j\right)\right]+W \tag{26}$$

$$p_j\left(c_j^h+q_j^m\right)\leq p_j\left(q_j+c_j^m\right)+e_j \tag{27}$$

$$f\left(\mathbf{q};Z_i^q\right)=0 \tag{28}$$

$$c_j,q_j,q_x\geq 0 \tag{29}$$

Equation (26) represents the budget constraint relating total household expenditure on consumption and farm inputs to total household income (revenue from sale of farm output and exogenous/non-farm income-W). Given that market participation decisions affect household utility through household's ability to satisfy food demand, we define equation (27) to represent balance of household food consumption which relates the value of self-produced goods used for household consumption and sold at market prices; to the value of farm produced goods, market purchased consumables, food obtained from other households and endowments such as positive inventories of food. Equation (28) represents the household's production technology while equation (29) represents non-negativity constraints on consumables, farm output and input.

[27]Labor supply decisions are ignored since the main focus of the chapter is on market participation decisions.

A key feature of the description above is that food consumed from own-farm output and market-purchased are equally valued-$p_\jmath$. This is as a result of the fact that in the absence of transactions costs (or at least where they do not impose binding constraints to market participation), household produced and market purchased goods are expected to be equally valued in prices (equality of market and shadow prices) and in utility since they are assumed to be perfect substitutes. As a result, they are not differentiated in the way they enter the the utility function. Analytically, this implies identical marginal utilities for household consumables irrespective of source- (first order conditions with respect to $c_\jmath^h$ and $c_\jmath^m$ all include the same $p_\jmath$).

To incorporate transaction costs, we define the following parametric prices (market prices adjusted for transaction costs) as done by Barrett (2008):

$$p_\jmath^{mb} = p_\jmath + \tau^c\left(S_\imath, A_\imath, G_k, W_\imath; c_\jmath^m\right) \qquad \forall c \tag{30}$$

$$p_\jmath^{ms} = p_\jmath - \tau^c\left(S_\imath, A_\imath, G_k, W_\imath, q_\jmath^m\right) \qquad \forall c \tag{31}$$

$$p_\jmath^a = p_\jmath \tag{32}$$

Where $p_\jmath^{mb}$ in equation (30) is the price for market purchases (including farm inputs); $p_\jmath^{ms}$ in equation (31) is the price received for market exchange of farm output; and $p_\jmath^a$ is the autarky or household shadow price. Furthermore, let $\theta_\jmath^b = 1$ for purchases of good $\jmath$ in a given time period; and 0 otherwise[28]; and $\theta_\jmath^s = 1$ for transactions involving sale of farm output of crop $\jmath$ in time period t; and 0 otherwise. The magnitude of transactions costs affect the extent to which $p_\jmath^{mb} \neq p_{\jmath t}^a$; and $p_\jmath^{ms} \neq p_\jmath^a$ and farmers' decision to participate in markets (as sellers of farm output or buyers of household consumables) or internalize food markets by self-producing.

Transaction costs (which are allowed to vary across different c markets resulting in differences in net returns across farmer market choice) are expressed as a

[28]Transactions costs effects on input purchases are not considered in this chapter thus we restrict our focus to purchase of household consumables and sale of farm output.

function of: S- Search costs; $A-$household assets, $G-$community factors/Public goods- such as roads, agricultural support services etc; W and $m_\jmath$as defined before-exogenous income and marketed surplus of crop $\jmath$ respectively. Although no specific functional form is imposed on the parametric price specification, reasonable assumptions are made about its first order conditions. For selling farmers, search costs increases transactions costs effects; household assets/endowments reduce transactions costs effects; improvements in rural infrastructure reduce transactions costs effects; and household wealth reduces transactions costs effects.

The redefinition of prices above in equations (30-32) expresses the nature of transactions costs. Using these definitions, we augment the benchmark model described above with transactions costs adjusted definition of market prices. As a result, household budget constraint defined in equation (26) and household balance of food demand defined in equation (27) of the basic model all change accordingly. The transactions costs adjusted household maximization problem thus becomes:

$$\max_{\mathbf{c},\mathbf{q}} \; U\left(\mathbf{c},;Z_i^c\right) \tag{33}$$

subject to the following constraints:

$$\left[\sum_{\jmath=1}^{J}\left[\left(p_\jmath^{mb}\left(c_\jmath^m.\theta_\jmath^b\right)\right)+\left(p_\jmath^a\left(c_\jmath^h\right)\right)\right]+\sum_{x=1}^{X}\left[\left(p_x^{mb}\left(q_x^m.\theta_x^b\right)\right)+\left(p_x^a\left(q_x^h\right)\right)\right]\right]\leq \tag{34}$$

$$\left[\sum_{\jmath=1}^{J}p_\jmath\left(q_\jmath-c_\jmath^h\right).\theta_\jmath^s\right]+W$$

$$p_\jmath^a\left(c_\jmath^h\right)+p_\jmath^{ms}\left(q_{\jmath t}^m.\theta_\jmath^s\right)\leq p_\jmath^a\left(q_\jmath\right)+p_\jmath^{mb}\left(c_\jmath^m.\theta_\jmath^b\right)+e_\jmath \tag{35}$$

$$f\left(\mathbf{q};Z_i^q\right)=0 \tag{36}$$

$$c_\jmath,q_\jmath,q_x\geq 0 \tag{37}$$

The presence of fixed transactions costs creates discontinuity in the maximization problem and thus obtaining optimal household decisions requires Kuhn-Tucker

conditions. In general, it can be observed from the redefined prices that transactions costs drive a wedge between market and shadow prices resulting in $\left(p_j^a \neq p_j^{mb}\right)$. This breaks down the substitutability of market and household produced goods (c_j^m and c_j^h) constraining households' ability to balance their food demand as specified in equation (35). The extent to which the constraint is binding is sensitive to the magnitude by which shadow prices differ from market prices- i.e. the size of transactions costs. High transactions costs resulting in constrained market participation can be relaxed by reducing reliance on markets to balance equation (35) which can be achieved through internalized markets by increasing the consumption of farm harvest (hence reducing the amount of farm harvest allocated for market exchange) and reducing the purchase of market goods. In this chapter, we focus on the former- the effect of transactions costs on farmers' use of farm harvest for market exchange and household consumption.

For farming households producing crops which can be used for market exchange or household consumption, this response establishes jointness in household decisions. This implies that production decisions such as crop choices and the marketing of farm output are affected by consumption decisions such as the proportion of household consumption obtained from farm harvest relative to volume of market purchases- i.e. the size of internalized food markets. As a result of this relationship, optimal demand and supply decisions which relate to household production (such as demand and supply of inputs) and consumption such as purchase of good and consumption of farm harvest are no longer a function of prices only (as in the case where transactions costs are absent) but also household attributes (taste shifters) which affect shadow prices such as indicators of the extent to which constraints on consumption are binding and risk-preferences. These decisions have implications household market participation- as buyers of goods for consumption, labor or other factors; and sellers of farm output or factors such as labor.

In summary, under transactions costs constrained market participation, constrained optimal household choices such as quantity of household consumption of own-farm output, market purchased goods for household consumption, and quantity of farm output used for market exchange are a function of factors other than market prices. This can be illustrated in the following sketches of the optimal solution for house-

hold demand and supply decisions[29]. These constrained optimal decisions are now functions of transactions costs adjusted market prices (instead of exogenous market prices) and household characteristics or taste shifters for the different regimes-non-participating households, buyers and sellers:

- $c_{\jmath}^{*h}\left(.p_{\jmath}^{a}\right)$;
- $c_{\jmath}^{*m}\left(.p_{\jmath}^{mb}\right)$;
- $q_{\jmath}^{*m}\left(.p_{\jmath}^{ms}\right)$;

$c_{\jmath}^{*h}\left(.p_{\jmath}^{a}\right)$ represents the constrained-optimal quantity of good $\jmath$ consumed from farm harvest as a function of transactions costs adjusted shadow price; whereas $q_{\jmath}^{*m}\left(.p_{\jmath}^{ms}\right)$ represents the constrained optimal marketed surplus of crop $\jmath$ as a function of transactions costs adjusted market prices. $c_{\jmath}^{*m}\left(.p_{\jmath}^{mb}\right)$ (which is not considered) in this chapter is the constrained-optimal quantity of good $\jmath$ consumed from market purchases.

Through these equations, we test the following hypotheses. Under binding constraints on market participation such that $p_{\jmath}^{a} > p_{\jmath}^{ms}$ farmers are not sufficiently incentivized to sell farm output and thus face constraints on their ability to balance household food consumption. Constrained optimal responses to these conditions such as non-participation and low intensity conditional on participation have been considered extensively in the literature. Non-participating households may choose to satisfy household food demand through the consumption of own-farm output to relax constraints on consumption decisions, Participating households (depending on the extent to which market participation constraints are binding), may chose a combination of own-farm output and market purchased goods. The use of household produced goods relaxes constraints on consumption decisions by reducing reliance on formal markets to generate returns from sale of farm output to finance consumption decisions or to purchase goods for household consumption. The extent to which constraints due to transactions costs are binding and hence

[29]We restrict out attention to supply and demand functions for consumption and marketed surplus. Other decisions such as use and purchase of inputs and labor are ignored but generally follow similar structure in the presence of transactions costs.

the need to internalize food markets through the use farm output for household consumption is expected to differ across farmers based on crop choices and diversity of crop portfolio.

Suppose crops produced by a given farmer can be further divided into food crops $f = 1, 2, \ldots, F$ (such as grains, and other household consumables-eggs, chicken, firewood, etc.) and market-exchange crops $k = 1, 2, \ldots K$ (such as coffee, etc) $\forall f \neq k$ and $f, k \in J$. Furthermore, output of f crops-q_{ft} are largely for household consumption (meaning $c_f^{*h} > q_f^{*m}$ or zero marketed surplus $q_f^{*m} = 0$; is possible). Whereas, output of k (q_k) is largely used for market exchange (meaning $q_k^{*m} > c_k^{*h}$). The quantity of f items household consumes-c_f can be obtained from: self-production-c_f^h; or market purchased- c_f^m. Households' choice to consume from own production-c_f^h rather than market-purchased-c_f^m, when driven by transactions costs which drive a wedge between market and shadow prices $\left(p_f^{mb} \geq p_f^a\right)$; follows utility maximization. Farmers derive a higher utility from internalized food markets for which participation is constrained by transactions costs. This influences crop choices and composition of crop portfolio since farmers which are less likely to be constrained by transactions costs may choose to produce cash crops; whereas farmers more concerned about household security choose to internalize more markets by diversifying their agricultural activities to reduce reliance on markets.

These differences imply that heterogeneity in the effects of transactions costs may occur due to differences in the gap between shadow prices of farm output and market prices of cash and non-cash crops and hence differences in market participation. Similarly, heterogeneity of in the effects of transactions costs on market participation due to differences in crop diversity may occur through differences in the gap between shadow and market prices. Increased diversity may result in greater food security which relaxes transactions costs effects.

3.3.3 Empirical Framework

The two-step technique proposed by Key et al. (2000) to solving the theoretical model defined above simplifies the estimation of households' market participation decisions. In the first step, households choose optimal consumption and produc-

tion decisions conditional on market participation. In the second step, households choose levels of participation which maximizes utility- i.e. intensity of participation. We implement similar approach on farmers' use of farm output for household consumption. Although household utility derived from participating (or not) in markets cannot be directly observed or measured, this technique helps define a suitable estimation procedure in which marketing decisions are defined as a two stage decision: the discrete choice of regime selection- seller or non-seller; and conditional on this decision, the continuous choice of intensity of participation can be observed from household data.

Transactions costs effects on market participation decisions differ both across households (due to differences in shadow prices which are a function of household characteristics) and also for any given household's decision to participate and the intensity of their participation. This further motivates a two-step estimation approach. This implies that two sets of parameters are of interest- the effect of observable factors of the probability of a given household's regime choice and the effect of similar factor (or perhaps different) on the intensity of household's participation.

Econometric Model

One way of estimating the two-stage market participation decisions of farming households is the two-stage Heckman model- Heckman (1976). In the first stage - the selection stage, the determinants of household's regime choice- seller versus non-seller/autarkic are examined using a probit model. In the second stage, the determinants of the intensity of participation conditional on participation are examined by using Ordinary Least Squares (OLS) to fit a quantity transacted regression controlled for selection bias using the inverse mills ratio (IMR) from the first stage probit. Goetz (1992b) among others have used this technique in this line of research. Others such as Renkow et al. (2004) propose a maximum likelihood approach since the restrictions required to achieve identification in the selection stage depend on unknown parameters to be estimated in the quantity transacted equation of the 2-stage selectivity model. However, the maximum likelihood estimation relies on restrictive assumptions to be more efficient that the traditional two-step process Wooldridge (2010).

In addition and perhaps the widely discussed shortcoming of the use of the traditional Heckman model in studies on market participation is that it considers non-participation of households as missing observations rather than corner solutions and uses this to control for selection bias in studies where market participants are of interest. However, under binding constraints to market participation due to transaction costs, non-participation by farmers may be optimal.

In light of this shortcoming, corner solutions models such as the traditional Tobit (due to Tobin (1958)) and modifications of it have been used. Some of the modifications include the censored tobit model which has been criticized in that a zero outcome of market participation is considered irrational choice (See Holloway et al. (2000)); the ordered Tobit (See Bellemare and Barrett (2006)). Holloway et al. (2004) propose non-zero censoring since under transaction costs assuming censoring at zero introduces bias in the parameters because a zero outcome maybe a corner solution (non-participation due to lower net-returns from participation driven by high transactions costs). The shortcoming of the tobit model (and by extension its modifications) is its restrictive assumption that both stages of farmers' marketing decision (regime choice and intensity of participation) are generated by the same process Wooldridge (2003).

In the context of this chapter, this assumption implies that the same set of covariates that affect farmer's discrete choice of market participation also affect the continuous choice of intensity of participation. However, given the theoretical motivation for the differential effects of fixed and proportional transactions costs on discrete and continuous marketing decisions, assuming homogeneity as required by the Tobit model may be restrictive. For instance, while both fixed and proportional transaction costs may affect farmers' discrete marketing decision, however, farmers' continuous marketing decision conditional on participation is likely to be largely driven by proportional transaction costs Key et al. (2000). Thus, a modification of the Tobit model which allows both decisions to be determined by separate processes is required. Cragg (1971) proposed the Cragg truncated normal Double Hurdle model (due to Cragg (1971)) relaxes the restrictive assumption of the Tobit model to allow for separate processes.

Following Wooldridge (2010), we define the following econometric model for market participation:

$$y_{\imath t} = X_{\imath t}\beta + \epsilon_{\imath t} \tag{38}$$

where $y_{\imath t}$ is the regime choice of a given household at a given time period (=1 for sellers and =0 for self-sufficient/non-selling households); and in the use of farm output for household consumption (1= use of farm output and 0 otherwise) expressed as a function of a vector of exogenous variables $X_{\imath t}$ (household and community characteristics which influence market participation); β are sets of parameters to be estimated. However, $y_{\imath t}$ is only observed for sellers when the sales index or proportion of household consumption obtained from household produced goods: $s_{\imath t}$(to be defined below) is greater than zero for a given household $\imath$. We define sellers are those households that realize a non-zero quantity of farm output of which they sell a positive quantity; non-sellers on the other hand are those households with a non-zero quantity of farm output but do not sell a positive quantity[30].

$$s_{\imath t} = Z_{\imath t}\theta + A_{\imath t}\vartheta + \varepsilon_{\imath t} > 0 \tag{39}$$

where $Z_{\imath t}$ is a set of explanatory variables (household and community and market characteristics which influence intensity of market participation); θ is a vector of parameters to be estimated.

Following Cragg (1971),$\epsilon_{\imath t}$ and $\varepsilon_{\imath t}$ are assumed to be normally distributed with zero covariance and conditionally independent. The assumption of conditional independence of the errors has been seen as being restrictive in some applications of the double hurdle model (Garcia and Labeaga (1996); Jones (1992)). However, even when such assumption is relaxed, the results obtained have not significantly differed from results from the original assumption.
Similar to implementing the Heckman 2-stage model and following Wooldridge (2010) the double hurdle model is estimated in two stages/tiers (Equations (38) and (39)). In the first stage, the regime choice is estimated to follow a probit

[30]Because our data is restricted to production data, regime choice is restricted to sellers and non-sellers; purchase decisions are excluded.

model (such that $P(y_{it}=1|X_{it})=\Phi(X_{it}\beta)$) and in the second stage, the intensity of participation is estimated to follow a truncated normal distribution[31]. Thus, the general formulation of the Cragg model integrates a probit model into a truncated normal model resulting in the following density function:

$$f(y_{it},s_{it}|X_{it}Z_{it})=\{1-\Phi(X_{it}\beta)\}^{1(y=0)}\left[\Phi(X_{it}\beta)(2\pi)^{-\frac{1}{2}}\sigma^{-1}\exp\left\{-(s_{it}-Z_{it}\theta)^2/2\sigma^2\right\}/\Phi(Z_{it}\theta/\sigma)\right] \tag{40}$$

Taking the log of the above density functions yields the log-likelihood function. Maximum Likelihood Estimation technique is used to select β, θ and σ values which is maximized the log-likelihood function. Since there are no restrictive assumptions imposed on the parameters, the Maximum Likelihood estimator for β,$\hat{\beta}$ is the probit estimator for $y_{it}\equiv 1[s_{it}>0]$ on X_{it}; and $\hat{\theta}$ can be obtained from the Maximum Likelihood Estimator from the truncated normal regression[32]. From the above, the following expressions can be obtained:

$$P(s_{it}=0|X_{it})=1-\Phi(X_{it}\beta) \tag{41}$$

$$P(s_{it}>0|X_{it})=\Phi(X_{it}\beta) \tag{42}$$

$$E(s_{it}|s_{it}>0,Z_{it})=Z_{it}\theta+\sigma*\lambda(Z_{it}\theta/\sigma) \tag{43}$$

$$E(s_{it}|X_{it},Z_{it})=\Phi(X_{it}\beta)[Z_{it}\theta+\sigma*\lambda(Z_{it}\theta/\sigma)] \tag{44}$$

where $\lambda(Z_{it}\theta/\sigma)=\phi(Z_{it}\theta/\sigma)/\Phi(Z_{it}\theta/\sigma)$ is the Inverse Mills Ratio (IMR) and σ-sigma is obtained from maximizing the log-likelihood function defined in the econometric model andϕ is the standard normal probability distribution function (Burke (2009)). Equations (41) through (44) are: probability of not selling; probability of selling; average partial effect on intensity of participation conditional on selling; and unconditional average partial effect on intensity of participation respectively. To identify transactions costs and participation in informal market effects on farmers' marketing decisions, the following empirical issues require attention.

[31]The model was also estimated using Probit and OLS for the two stages respectively. The parameter estimates from the OLS estimation differ from those of the truncated normal regression. Results are presented in the Appendix.

[32]Joint estimation of the two stages of the Double Hurdle model in Stata is facilitated by Burke (2009)

Defining Market Participation

Farming households in rural Ethiopia produce multiple crops which differ across households and overtime; and also across space making a study of marketing of farm output for individual crops empirically challenging. Furthermore, it is expected that the marketing decisions of farm output overlap across crops produced by a given household. For these reasons, we define market participation at household level. A sales index for participating households is calculated as the proportion of total farm output sold of a given crop (i.e. marketed surplus) which is aggregated across all crops produced by a given household in a given farming period. On the other hand, non-sellers/autarkic farmers produce a non-zero quantity but do not sell a positive quantity of farm output. The use of an index is motivated by the following features of the data:

- Quantities of output for each crop are expressed in local units whose conversion factors to standard units differ across crops and communities. However, the quantity sold is measured in similar units with the quantity of output making it easy to obtain sales index at crop level.
- Certain households hold multiple plots of similar crops for which they may choose to sell output from one plot but report zero sales from another plot. This creates the possibility of multiple regimes for a single crop in a given household making analysis quite complicated.

More precisely, household sales/marketing index is calculated as follows:
Sales Index for a given crop $\jmath$ produced by household $\imath$ for which a quantity of $q_\jmath$(in local units) is produced and $m_\jmath$(in local units) is sold.

$$s_{\jmath t} = \left(\frac{m_{\jmath t}}{q_{\jmath t}}\right) \qquad \forall j \in J_\imath \, \forall t \tag{45}$$

Household sales index is arrived at by calculating the average sales index from all the crops in its portfolio thus converting the plot/crop level data to household level.

$$I_{it}^{s} = \left(\frac{\sum_{j=1}^{J} s_j}{\sum_{j=1}^{J} J} \right) \quad \forall i \forall t \tag{46}$$

Apart of selling farm output, we also consider the use of farm output for household consumption. We define the size of households' internalized markets using information about the components of households' consumption basket. As highlighted before, we assume that household consumption is satisfied through market purchased (c_k^m), household produced goods $\left(c_k^h\right)$ and gifts and exchanges with other households (c_k^e) indexed by k. The size of internalized food markets is defined as an index constructed from the proportion of total consumption of each item obtained from own harvest of the household. For each item a given household reports to have consumed, we obtain the proportion of it obtained from the household's farm output. This is then averaged across all items consumed by the household in a given period to obtain the size of internalized markets. By this construction, the index of households' consumption of own harvest is bounded between 0 and 1.

$$c_{it}^{h} = \left(\frac{\sum_{k=1}^{K} c_k^h}{\sum_{k=1}^{K} \left(c_k^h + c_k^m + c_k^e \right)} \right) \quad \forall i \forall t \tag{47}$$

The motivation for this measure is to obtain an indication of the extent to which households rely on self-produced goods for household consumption and its sensitivity to the presence of transactions costs. It is important to highlight that this measure suffers from a couple of limitations. Information such as the existence of markets for goods used for household consumption and differences between items (self-produced and market purchased goods in consumption basket among others are not captured by the index. This is largely due to limitations in the data. We therefore interpret the results of transactions costs effects on use of farm harvest for household consumption with these concerns in mind.

Defining Transaction Costs

As mentioned earlier, following earlier work in the literature, transactions costs are divided into fixed and proportional/variable costs. In addition, as highlighted in Renkow et al. (2004), studies of this nature may be motivated by two objec-

tives: measuring the size of transactions costs, or examining the degree to which transactions costs affect households' market participation decisions. This chapter focuses on the latter in the context of farming-households producing crops used for both household consumption and market exchange. However, the challenge with examining the effect of transaction costs (as mentioned in numerous works such as Key et al. (2000)) is the unobservable nature of such costs. Transactions which do not occur due to high transaction costs are not observed and where market participation occurs, recording transactions costs such as search costs, bargaining costs etc is difficult. With the objective of examining the extent to which transactions costs affect marketing decisions (and not quantifying such costs), indicators of transactions costs from household and community characteristics can be used. Based on these characteristics, Fixed and Proportional Transactions Costs can be identified and used in the analysis of market participation among households. Following Key et al. (2000), Fixed Transactions costs are defined as costs associated with search and bargaining efforts and can be identified from indicators of community connectedness with markets (state of rural infrastructure and public goods) and/or household head's attributes relating to marketing ability and experience. Proportional Transactions costs on the other hand are associated with distributions costs and thus identified from transportations costs among other costs which vary with quantity of farm output transacted.

Although all these indicators of transactions costs are included in our analysis, the focus is on distance to market and distance to major town as two main indicators of transactions costs in the literature. Distance to market encompasses various indicators of transactions costs-both explicit such as transportation costs; and implicit such as opportunity costs of time spent in transacting farm output or purchasing goods for household consumption. This perhaps justifies its popularity in the literature. The other main indicator of transactions costs is distance to major town which captures information about market integration, access to bigger markets with more clientèle for selling farm output and more sellers of goods for household consumption; and possibly better deal in terms of prices.

Crop Diversity Index

We construct an index of crop diversity using information about the number of food and cash crops produced such that the measure of diversity increases with the

Table 15: Transactions Costs Indicators

Variable	Explanation	Name of Variable
Fixed Transactions costs.		
Household Head's Age	Older household heads are likely to have greater experience and perhaps better search and bargaining skills	Hh. Head's age
Agric. Cooperatives, Extension Services and Local Association Membership of Household Head	These factors jointly enhance access to information and thus lower search costs. In addition, Cooperatives facilitate group marketing- See Staal et al. (1997),Holloway et al. (2000) and Alene et al. (2008).	Agric. Cooperative; Agric. Extension service; IDDIR Member.
Distance to market and major town.	Communities closer to markets and major towns are expected to be more connected with other markets and thus face lower transportation costs, and lower effort in searching for higher prices. SeeFafchamps (1992), Jayne (1994) , Omamo (1998b) and Barrett (2008)	Distance to mkt (in km); and Distance to major town in (km).
Proportional Transactions Costs.		
Improvements in road and market conditions.	Communities with improvements in road and market conditions or have better road networks are expected to face lower transportation costs since less time is spent in distributing farm output.	Better road; and Improved mkt.
Farmers choice of market	Differences in intensity of participation across markets differentiated by distance (participants of village markets relative to other markets) may be driven by differences in transactions costs. SeeVakis et al. (2003)	Village mkt Seller.
Cart ownership	In societies where carts are important means of transport, cart owners are expected to be able to transport larger amount of farm output and thus face lower per unit transportation costs. SeeGoetz (1992b)	Cart owner.

number of food $\left(q^f\right)$ and cash (q^c) crops produced out of the set of major food and cash crops considered in our analysis-$\jmath^f = \{teff, barley, wheat, maize, sorghum\}\, and \jmath^c = \{coffee, chat\}$. These crops represent the major food and cash crops produced in Ethiopia (Taffesse et al. (2011)). The proportion of food and cash crops produced out their respective subsets is weighted to ensure that the index of crop diversity sums up to one.

$$\jmath_{\imath t} = \theta_f \left(\frac{\sum_{q^f=1}^{F} \left(q^f\right)}{\jmath^f} \right) + \theta_c \left(\frac{\sum_{q^c=1}^{C} \left(q^c\right)}{\jmath^c} \right) \tag{48}$$

Where $\jmath_{\imath t}$ is the measure of crop diversity for farmer $\imath$ in period t.; and θ_f and θ_c represent weights which sum up to 1.

3.3.4 Data

The Ethiopia Rural Household Survey (ERHS) is longitudinal household dataset which is representative of rural Ethiopia. Data collection started in 1989 with follow up rounds in 1994, 1995, 1997, 1999, 2004 and 2009. Over the years, the coverage of the survey has been expanded from an initial number of 6 administrative units to 15 across 4 of Ethiopia's 11 regions surveying 1,477 households. See Dercon (2004a) for a detailed discussion of the dataset. We use 3 rounds (over a period of 10 years) of the survey (ERHS) (1999, 2004 and 2009) to form a balance panel of **699 households** with data on their market participation (i.e. sale of farm output), wealth/assets, demographics and community infrastructure. A description of each variable is provided in table (22) in the Appendix.

Table 16: Summary Statistics: Selected Variables- Rounds 5-7 of ERHS (1999-2009)

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Mkt. Participation (seller=1)	0.616	0.487	0	1	2097
hh. sales index	0.340	0.236	0.001	1	1291
use farm harvest (=1)	0.850	0.357	0	1	2097
Prop. of Self-produced Consumed Items	0.305	0.160	0.043	1	1807
Prop. of Qty. obtained from harvest (all items)	0.144	0.116	0.001	0.807	1783
Prop. of Qty. obtained from harvest	0.809	0.257	0.030	1	1783
Hh. head's age	53.305	15.994	11	100	2097
Hh. head (male=1)	0.578	0.494	0	1	2097
Hh. size	5.397	2.675	1	18	2088
Number of plots	5.109	2.511	1	17	2097
Tropical Livestock Units	2.292	4.224	0	38.38	2097
IDDIR member (=1)	0.248	0.432	0	1	2097
Food price Index (Deviation from avg.)	0.49	1.125	-0.642	2.324	2097
Agric. cooperative (=1)	0.66	0.474	0	1	2097
Agric extension Service (=1)	0.853	0.354	0	1	2097
Distance to mkt. (in km)	4.855	5.848	0	36	2097
Distance to major town (in km)	9.420	6.541	0	25	2097
Number of mkts in Community	1.943	1.918	0	9	2097
better road (=1)	0.642	0.479	0	1	2060
improved mkt. (=1)	0.492	0.5	0	1	2097
Choice of mkt. (village mkt=1)	0.298	0.458	0	1	1291
cart owner (=1)	0.103	0.304	0	1	2097
Crop diversity Index (Food & cash crops)	0.271	0.145	0	0.917	2097
Crop diversity Index (Food Crops only)	0.322	0.191	0	1	2097
Cash crop farmer (=1)	0.14	0.347	0	1	2097

Allocation of Farm output: Market Exchange and Household Consumption

As reported in the descriptive statistics above, on average, 61% of farmers in the data participate in markets as sellers. However, on average, only 34% of farm output is sold by sellers which by some measure, indicates low intensity of participation. This phenomenon is typical in many rural areas of the developing world and serves as the motivation for this area of research- See Weber et al. (1988) for a discussion of policies targeting increased agricultural commercialization. The use of household produced goods for household consumption also appears to be common among farming households in rural Ethiopia. On average, 85% of farmers in the data used farm harvest for household consumption. However, as a proportion of total number of items consumed by the household (household consumption basket), the use of farm output for household consumption is fairly small. On average, over 30% of total items consumed by households is obtained from household production.

These measures are aggregated at household level and thus may not illustrate the extent to which households rely on farm harvest for household consumption. To facilitate this, an item level analysis of the contribution of farm output to the quantity each item consumed by the household is conducted. Of items for which farm harvest is used, the average share of farm harvest of the quantity consumed is 80%. This implies that for self-produced goods which are used for consumption, the household relies mostly on its farm harvest; and less on other sources such as market purchases or gift exchanges and barter. The dependence on farm harvest for the consumption of these items may result from the presence of transactions costs which break the substitutability of farm harvest of such items and similar market goods. As a result, households tend to internalize the markets for such items through the use of farm harvest.

The reliance on farm harvest for household consumption appears to be true for certain items and not all items in the household consumption basket. This is indicated by the fact that, across all the items consumed by households, an average of 14% of the quantity consumed is obtained from farm harvest. Thus, on average households in the data do not appear to be completely autarkic but possibly net-

buyers. The extent to which households rely on markets for consumption may be affected by transactions costs through the size of internalized markets indicated by the number of items and quantity consumed by the household using farm harvest; or through net returns on market exchange of farm output. We investigate these issues in the chapter.

Indicators of Transactions Costs

As highlighted above, the presence of transactions costs is identified from household and community characteristics which indicate market accessibility and ease of market participation. The average distance to markets is 4.855km; whereas the average distance to a major town is 9.4km. Differences in distance to market and major are expected to influence participation decisions through cost of participation. It also observed that almost 30% of farmers sell farm output in village markets which are expected to be in closer proximity to households compared to other market outlets especially given that ownership of a means of transport (such as a cart) is low among farmers in the data.

Other indicators of transactions costs such as markets and road conditions appear to have improved for more than half of the farmers in the data. Similarly, agricultural support services such as extension services and cooperatives appear to be common in most communities. Other household characteristics such as membership of IDDIR (funeral societies) which is expected to affect search costs through access to information vary across households. On average, 25% of households are members of such associations.

Differences in Crop Choices and Diversity of Crop Portfolio

We also examine the heterogeneity of transactions costs effects on market participation across farmers based on differences in choice of crop and diversity of crop portfolio. We investigate whether cash crop farmers relative to other farmers are less likely to be constrained by the presence of transactions costs or not. Similarly we consider the effect of differences in crop diversity on the extent to which transactions costs constrain market participation. It is observed that on average 14% of farmers in the data are coffee producers- a popular cash crop. This indicates

the dominance of food and other non-cash crop production among farmers and perhaps explain the low intensity of participation among sellers of farm output. In terms of crop diversity, it also appears that farmers tend to diversify food crop production more intensely that food and cash crop. The indexes of both measures indicate that the latter is larger on average.

Differences between Sellers and Non-Sellers.

Before estimating our model of transactions cost effects on market participation, we examine the characteristics of sellers and non-sellers and the extent to which such differences illustrate transactions costs effects. For instance, differences in household characteristics which indicate household's search skills, experience, access and ability to obtain information can influence marketing decisions through farmers' ability to relax constraints due to transactions costs. In addition to household factors, differences in the status of rural infrastructure/public goods such as road conditions, distance to major town, proximity to markets; and agricultural support services such as extension services and agricultural cooperatives are examined. Below is t-test on the significance of the differences in the means of household and community characteristics of sellers and non-sellers. Since majority of the farmers in the data (on average 85%) use farm harvest for at least one item consumed, we do not conduct a test of differences in means across farmers based on their use of farm output for household consumption.

The table shows that sellers and non-sellers significantly differ in terms of distance to market and major town which as highlighted above are main indicators of transactions costs. The difference in distance to market appear to be particularly large- on average, the distance to market for sellers is 3.8km compared to 6.5km for non-sellers. Other differences which are likely to influence the extent to which market participation is constrained include: differences in improvements in roads and markets, and availability of cooperatives. These differences illustrate that transactions costs to market participation indicated by these characteristics are lower among sellers.

At household level, differences between sellers and non-sellers include scale of crop diversity, number of plots and membership of IDDIRs. On average, sellers appear to have more diverse crop portfolios, more plots and members of IDDIRs than

Table 18: Test of Differences in Means of Sellers & Non-Sellers

	Non-Seller	Seller	
Variable	**Mean**	**Mean**	**p-value**
Hh. head's age	53.064	53.456	0.585
Hh. head (male=1)	0.543	0.600	0.010
Hh. size	5.536	5.310	0.061
Number of plots	4.143	5.712	0.000
Tropical Livestock Units	2.214	2.341	0.505
IDDIR member (=1)	0.195	0.282	0.000
Food price Index (Deviation from avg.)	0.499	0.485	0.782
Agric. cooperative (=1)	0.619	0.685	0.002
Agric extension Service (=1)	0.862	0.847	0.349
Distance to mkt.	6.525	3.813	0.000
Distance to major town	10.557	8.712	0.000
Number of mkts in Community	2.022	1.893	0.133
better road (=1)	0.593	0.673	0.000
improved mkt. (=1)	0.413	0.541	0.000
cart owner (=1)	0.103	0.103	0.997
Coffee farmer (=1)	0.043	0.201	0.000
Crop diversity Index (Food & cash crops)	0.229	0.297	0.000
Crop diversity Index (Food Crops only)	0.284	0.347	0.000

non-sellers. However, differences in wealth (measured using livestock units) are statistically insignificant.

Therefore, preliminary examination of the data seems to suggest that differences in the scale of agricultural commercialization among farmers in Ethiopia may be driven by differences in the extent to which market participation is costly. This motivates the need to examine the extent to which transactions costs affect market participation and the heterogeneity of such effects across farmers based on their crop portfolio- choice of crop and diversity.

3.4 Results

To interpret the results from the estimated double-hurdle model, the Average Partial Effects (APEs) are used. The APEs are obtained from the partial effects on participation and intensity of participation for each variable in the model is obtained using techniques discussed in Burke (2009). The derivation of the partial effects is provided in the Appendix. The tables with the estimated coefficients (not the APEs) are presented in the Appendix.

We examine transactions costs effects on market participation by estimating two specifications of our model: one for marketing of farm output and the other for use of farm harvest for household consumption. This is followed by examining the heterogeneity of transactions costs effects between cash crop and non-cash crop producers; and by incorporating differences in crop diversity.

3.4.1 Transactions Cost Effects on Market Participation

Table 20: Transactions Costs Effects on Market Participation: Average Partial Effects

	Mktn. of Farm output		Use of Farm output for Hh. Cons.	
VARIABLES	Stage 1	Stage 2	Stage 1	Stage 2
Hh. head's age	-9.63e-05	0.000435	0.000256	8.34e-05
	(0.000667)	(0.000405)	(0.000435)	(0.000186)
Hh. size	-0.00832**	-0.00567**	-0.00157	-0.000490
	(0.00419)	(0.00263)	(0.00265)	(0.000918)
Number of plots	0.0497***	-0.0201***	0.0273***	0.00508***
	(0.00526)	(0.00351)	(0.00386)	(0.000836)
Tropical Livestock Units	0.00513*	-0.00222	-0.000131	0.00135**
	(0.00272)	(0.00170)	(0.00195)	(0.000549)
Food price Index (Deviation from avg.)	0.0443	-0.306***	-0.315***	0.0824***
	(0.0782)	(0.0646)	(0.0608)	(0.0215)
Distance to mkt. (in km)	-0.0126***	-0.00546*	-0.0122***	0.00279***
	(0.00234)	(0.00283)	(0.00102)	(0.000907)
Distance to major town (in km)	-0.00711***	-0.00389***	-0.000189	-0.000851**
	(0.00170)	(0.00151)	(0.00112)	(0.000420)
Number of mkts in Community	-0.0321***	0.00675	0.00269	-0.0118***
	(0.00591)	(0.00515)	(0.00328)	(0.00178)
Hh. head (male=1)	0.0255	0.0226*	0.0518***	-0.00333
	(0.0197)	(0.0131)	(0.0150)	(0.00515)
IDDIR member (=1)	0.0642**	0.0557***	-0.0143	-0.0161**
	(0.0279)	(0.0185)	(0.0223)	(0.00796)
Agric. cooperative (=1)	0.105***	-0.0378**	0.0362**	0.0387***
	(0.0250)	(0.0173)	(0.0169)	(0.00616)
Agric extension Service (=1)	-0.0191	0.0267	-0.0595***	0.0180***
	(0.0339)	(0.0207)	(0.0193)	(0.00525)
Village mkt seller (=1)		0.0632***		-0.0108*
		(0.0217)		(0.00607)
cart owner (=1)		-0.0171		0.000806
		(0.0240)		(0.00908)
better road (=1)		0.0341**		-0.0272***
		(0.0143)		(0.00690)
improved mkt. (=1)		0.0798***		-0.0244***
		(0.0283)		(0.00701)
Observations	2,051	2,051	2,051	2,051
chi2	217.8	217.8	264.6	264.6
Log likelihood	-889.9	-889.9	1269	1269

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Marketing of Farm Output

We begin by examining transactions cost effects on farmers' use of farm output for market exchange.

As highlighted in the discussion about the identification of transactions costs, distance to markets has been a popular indicator of transactions costs in the literature. The average partial effects reported above show that an increase in distance to market is associated with a decrease in the probability of farmers participating as sellers by 1.26%. The effect conditional on participation (i.e. among sellers of farm output) is smaller but statistically significant- the intensity of participation of sellers decreases by 0.546% on average.
Distance to major town also has similar effect on market participation of farmers. All else equal, increase in distance to major town lowers the probability of participating as sellers by 0.711% on average. The effect on the intensity of participation among sellers is smaller- a decrease of 0.389% in the proportion of farm output sold is expected.

These results indicate that transactions costs due to distance to market (such as transportation costs) appear to constrain market participation through farmers' discrete choice of participating or not. The effect of both measures of distance to market is larger on farmers' first stage market participation decision. Conditional on participating, the effect of distance to market and major town are both very small albeit statistically significant. This is further reflected in the intensity of participation in village markets relative to other market outlets. On average, farmers participating as sellers, sell 6.32% more of farm output in village markets relative to other markets. Drawing from the work by Vakis et al. (2003) that farmers' choice of market can be used to identify the role of transactions costs, the intensity of participation in village markets (which are in terms of distance closer than say regional markets) might be influenced by the presence of transactions costs.
While the effect of distance to market can be interpreted as the role of transportation, and other costs associated with participating in a given market, the effect of distance to major town on marketing of farm output can be interpreted in several

ways since it relates to the connectedness of the community (or its markets) to other communities and markets. Major towns are by virtue of their population are likely to have larger and more integrated markets. This implies access to wider customer base and thus lower search costs for both selling farm output and purchasing goods for household consumption. As a result, farmers in communities closer to major towns are likely to benefit from lower transactions costs in accessing larger and more developed markets thereby increasing incentives to participate more intensely. Previous studies such as Fafchamps (1992) have reported that due to market segmentation, farmers' face price risk which lowers incentives to produce cash crops relative to food crops. These effects are more severe in communities where price and yield are highly correlated. Thus, as markets become more integrated, price risk and the correlation between price and yield is potentially lowered thereby increasing farmers' incentive to produce cash crops and increase their scale of agricultural commercialization.

In addition to distance, the effect of the state of community and market infrastructure such as improvements in road and market conditions on marketing of farm output (especially among sellers) have also been considered. These indicators of transactions costs appear to have a larger effect on market participation than distance to market. Farmers in communities with improved market conditions are likely to sell 7.98% more of farm output relative to those in communities without such improvements. Similarly, all else equal, an improvement in road conditions is associated with an increase intensity of participation by 3.41% on average. Improvements in roads and markets are likely to influence market participation by lowering opportunity costs of the time spent selling farm output, search costs, transportation costs etc. of sellers thereby increasing the intensity of participation. These results also illustrate the importance of market infrastructure (in addition to community infrastructure such as roads which is often considered in the literature) on agricultural commercialization. The improvements in the infrastructure of markets which may occur in the form of the provision of stalls, expansion of size of the market among others are likely to ease the participation of farmers in selling farm output as shown in the results. The size of the gains from these improvements measured in terms intensity of participation are large especially when compared to the gains from improved road conditions.

At household level, differences in production capacity and wealth proxied by number of plots and livestock units respectively; and membership of a local association (IDDIR) also affect farmers' discrete market participation decisions. Farmers with more land area and livestock are on average more likely to participate as sellers. This may result from the fact that constraints on market participation due to transactions costs are less likely to be binding for farmers with more land or livestock endowments. With a large farming area, farmers can produce several crops thereby reducing the impact of transactions costs at the household level since average transactions costs across all crops produced is likely to be lower. Farmers with livestock on the other hand are less likely to be constrained by lower net-returns from market change due to transactions costs since livestock can facilitate consumption smoothing when faced with lower income from market exchange.
It is also observed that members of local associations are likely to participate as sellers of farm output. Membership in local associations is likely to influence market participation through access to information about prices and markets from co-members of local associations. Several studies in the literature on social networks have documented the effectiveness of these associations as channels for information sharing. Another possible explanation for the effect of IDDIR membership on marketing of farm output is financial obligations to the association. Members obliged to make periodic contributions are likely to sell farm output in order to fulfill their obligations and to avoid penalties. However, we do not investigate this possibility further.

In the existence of jointness in household production and consumption decisions, food prices and its volatility are likely to influence marketing of farm output decisions. This issue has been considered by Fafchamps (1992). The results indicate that deviation of food prices from average overtime have a significant effect on the intensity of participation. Increase in food prices from the average overtime decreases the proportion of farm output sold by upto 30%. Fafchamps (1992) interpreted this effect as a signal to food scarcity due to rising food prices and hence the need to internalize food markets through the use of farm harvest for household consumption. This relationship between production and consumption decisions which creates the possibility of internalizing markets through farm harvest per-

haps explains the negative effect of household size on market participation. All else equal, larger households (who are likely to have a larger food demand) are less likely to sell farm output and among sellers, the volume of output sold decreases as household size increase.

Use of Farm Harvest For Household Consumption

As with the analysis of transactions costs effects on the marketing of farm output, we examine the effect of transactions on market participation through farmers' use of farm harvest for household consumption.

The effect of distance to market on farmers' discrete choice of using farm output is counterintuitive- increase in distance to market, is expected to decrease the probability of using farm harvest for household consumption by 1.22%. This is perhaps because there is very little variation in farmers' discrete choice of using farm harvest for household consumption due to its popularity among farmers. Thus the focus of the analysis is on the effect of transactions costs on the volume of household consumption obtained from own-farm harvest.

Distance to market increases the farmers' use of farm harvest for household consumption. However, in terms of magnitude, the effect is small- increase in distance to market increases the proportion of household consumption obtained from farm harvest by 0.279%. The larger effect among the indicators of transactions costs is observed in improvements in roads and market conditions. Both improvements are associated with a decrease of 2.72% and 2.44% respectively in the proportion of household consumption obtained from farm harvest. These improvements are likely to ease access to markets by lowering transactions costs thereby increasing incentives to sell farm output and purchase market goods for household consumption.

Similar to market exchange of farm output, changes in food prices also have a significant effect on farmers' use of farm output for household consumption. Increase in food prices relative to average price levels increases the proportion of farm harvest as a composition of total household consumption by 8.24%. This result is in line with the effect of food prices on market exchange discussed above

and results from previous studies such as Goetz (1992b). All else equal, as food prices increase, farmers' ability to balance household food demand is constrained. The presence of transactions costs to market participation is likely to reinforce this effect further constraining households' consumption decisions. As a result, farmers have incentives to internalize food markets by increasing their inventory of farm harvest for household consumption thereby reducing reliance on formal markets. The magnitude of the effect compared to other covariates illustrates the role of food prices in farmers' market participation decisions and is possibly influenced by the non-separability of household decisions.

3.4.2 Heterogeneity of Transactions Cost Effects

Below we examine the extent to which constraints to marketing of farm output due to transactions costs differ across farmers based on differences in choice of crop (cash versus non-cash crop) and diversity of crop portfolio. We focus on differences in the effect of specific indicators of fixed and proportional transactions costs. For fixed transactions costs, we consider distance to market and distance to major town; and for proportional transactions costs, we consider improvements in road and market conditions. In the interest of space, we present below the estimated coefficients of the key variables only. The remaining variables as reported in the previous specification are omitted from the table.

Table 21: Heterogeneity of Transactions Cost Effects on Marketing of Farm Output For Cash & Non-Cash Crop Farmers and Differences in Crop Diversity

	Mktn. of Farm output		Mktn. of Farm output		Mktn. of Farm output		Mktn. of Farm output	
VARIABLES	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
Distance to mkt. (in km)	-0.0126***	-0.00546*	-0.0112***	-0.00473	-0.0257***	-0.00481	-0.0119***	-0.00417
	(0.00234)	(0.00283)	(0.00147)	(0.00366)	(0.00479)	(0.00619)	(0.00186)	(0.00298)
Distance to major town (in km)	-0.00711***	-0.00389***	-0.00567***	-0.00383***	-0.00721**	-0.00755***	-0.00705***	-0.00360***
	(0.00170)	(0.00151)	(0.00190)	(0.00122)	(0.00313)	(0.00235)	(0.00156)	(0.00126)
Distance to mkt.* cash crop	**0.0339**	**-0.00267**						
	(0.0224)	(0.00987)						
Distance to Town* cash crop	**0.0127**	**0.000431**						
	(0.00916)	(0.00329)						
Distance to mkt.* crop diversity					**0.0726*** **	**0.00550**		
					(0.0224)	(0.0212)		
Distance to Town* crop Diversity					**0.000858**	**0.0133**		
					(0.0120)	(0.0104)		
better road (=1)		0.0331**		0.0464***		0.0277*		0.0345
		(0.0153)		(0.0164)		(0.0155)		(0.0300)
improved mkt. (=1)		0.0776***		0.0781***		0.0703***		0.158***
		(0.0298)		(0.0296)		(0.0259)		(0.0446)
better road* Cash Crop				**-0.0506****				**-0.0412**
				(0.0255)				(0.0925)
improved mkt.* Cash Crop				**0.000828**				**-0.254*****
				(0.0299)				(0.0947)
Observations	2,051	2,051	2,051	2,051	2,051	2,051	2,051	2,051
chi2	233.5	233.5	223.1	223.1	234.5	234.5	222.2	222.2
Log likelihood	-861.8	-861.8	-863.8	-863.8	-876.1	-876.1	-880.3	-880.3

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Note: Other variables as reported in table (20) were also included in each specification.

Cash Crop Vs. Non- Cash Crop Producer

The effect of distance to market on farmers' discrete market participation decision is not significant for cash crop producers. Non- cash crop farmers on the other hand, are 1.13% less likely to participate as sellers than cash crop farmers following an increase in distance to market. The effect of distance to major town also has similar effect albeit smaller in magnitude. Thus transactions costs due to distance to markets are more likely to constrain non-cash crop farmers than cash crop farmers. In general, farm output of cash crops such as coffee is often used for market exchange, thus producers of cash crops are more likely to participate as sellers since the choice of producing cash crops is indicative of their commercial orientation.

However, conditional on participating, the effect of distance to market does to seem to significantly affect the intensity of participation between cash and non-cash crop farmers. This does not seem to be the case with distance to major town which again might be as a result of the fact that cash crops are often produced for market exchange. Non-cash crop farmers are more likely to face binding constraints due to distance to a major town in both their discrete and continuous market participation decisions relative to cash crop producers. These results illustrate the heterogeneity of transactions costs effects measured through distance to market on cash and non-cash crop farmers' decision to sell farm output and the volume to sell. In addition, the two measures of distance to market also illustrate differences in transactions costs effects on market participation- cash crop farmers appear to be less likely to be constrained by distance to market (both community market and larger markets of major towns) relative to non-cash crop farmers.

Non-cash crop farmers on the other hand appear to gain more from improvements in road conditions and markets. These improvements have a large positive effect on the participation of non-cash crop farmers. Better roads increase the intensity of marketing farm output of non-cash crop farmers by 4.64% relative to cash crop farmers. Improvements in market conditions on the other increase non-cash crop farmers' participation by 7.81% relative to cash crop farmers. These results are in line with the results from the analysis in the preceding section in which it was

observed that in addition to community infrastructure such as road conditions, market infrastructure also has a large effect on market participation of farmers-especially among non-cash crop farmers.

Therefore, it appears the presence of transactions costs to market participation is more likely to constrain non-cash crop farmers marketing of farm output. It is observed that distance to market lowers their participation whereas improvements in roads and market conditions increase the intensity of their participation relative to cash crop farmers. These differences possibly result from the magnitude of the difference between shadow and market prices due to transactions costs. This difference is expected to increase with farmers' ability to use output for household consumption.

Similarly, lower transactions costs such as improvements in road conditions and market access are expected to lower the gap between shadow and market prices (especially for food crops) thereby increasing incentives for market participation. For these reasons, cash crop farmers are expected to be less constrained by distance to market whereas non-cash crop farmers are likely to sell more farm output following transactions costs-reducing improvements in community infrastructure. Since cash crop output is often produced for market exchange, the presence of transactions costs is less likely to constrain market participation since incentives for alternative uses of farm output such as household consumption are lower. In the case of farm output of food crops, the possibility of using farm output for household consumption rather than market exchange exists. As a result of this, the size of the wedge between shadow and market prices of cash crops is likely to be smaller compared to non-cash crops since the substitutability of farm harvest of food crops and similar market goods is likely to decrease faster than the substitutability of farm harvest of cash crops with similar market goods. For instance, coffee as a cash crop is perhaps easily substitutable with similar coffee purchased from the market in addition to the fact as a composition of household consumption basket, it is likely to occupy a smaller proportion relative to other food items like cereals. Thus coffee farmers are less likely to be constrained by transactions costs in selling coffee since the incentives (in utility terms) for using coffee produced for household consumption are smaller. On the other hand, producers of cereals are

likely to have strong incentives to consume household harvest of where transactions costs are high and cereals are staple foods.

Differences in Diversity of Crop Portfolio.

The extent to which transactions costs constrain market participation of farmers also appears to be sensitive to the diversity of farmers' crop portfolio. Using an index of crop diversity constructed from the number of food and cash crops farmers produce, we examine the differences in transactions costs effects on marketing of farm output. As opposed to using a simple definition of number of crops, we use a weighted definition of food and cash crops.

The average partial effects above indicate that the effect of distance to market on farmers' discrete choice to sell farm output is sensitive to diversity of crop portfolio. The more diverse a crop portfolio is, the less likely market participation is constrained by distance to market. The effect of road conditions on market participation does not appear to significantly differ across farmers based on differences in diversity of crop portfolio. However, farmers with more diverse crop portfolios are expected to participate less intensely following improvements in market conditions. The heterogeneity of transactions costs effects on market participation due to differences in diversity of crop choices appears to be more noticeable in the case of distance to market.

The role of crop diversity in relaxing constraints on market participation due to transactions costs (especially distance to market) is likely to occur through farmers' reliance on markets to balance household food demand especially where household decisions are non-separable. Through the production of multiple food crops, farmers can internalize food markets thereby lowering the impact of transactions costs on their ability to finance consumption decisions. Thus farmers' with more diversified crop portfolios such as a farmers of food and cash crops are less likely to be constrained by transactions costs and thus participate as sellers. However, given that our definition of crop diversity index allocates weights to both food and cash crops, another more direct effect of diversification on transactions costs is possible. By producing several crops, farmers are able to reduce average marketing costs of farm output and hence ease market participation. For instance, farmers producing cash crops in addition to food crops are less likely to be constrained by

transactions costs in selling cash crop output. Using the results from the previous section, it is observed that distance to market constrains non-cash crop farmers' discrete choice of selling farm output but not cash crop farmers. Therefore, it is possible for a farmer with a diversified crop portfolio to relax constraints on her decision to sell farm output of food crops when she produces and sells cash crop output. This spill-over effect of marketing farm output of cash crops is likely to influence differences in the effect of transactions costs on market participation across farmers. This is very likely in developing countries diversifying crop production such as the addition of cash crops to farmers' crop portfolio is often done only after sufficient amount of food crops have been produced as reported by Fafchamps (1992). This is particularly the case where formal insurance markets are missing and farmers are exposed to risk of crop loss due to rain variation, pests etc. Under these conditions and the presence of transactions costs, farmers have incentives to produce several crops to minimize risk and ensure food security. Thus, an increase in the diversity of crop portfolio is likely to be associated with the addition of cash crops which is also likely to be associated with commercialized farming and hence lower probability of being constrained by transactions costs.

3.5 Robustness Tests

A major constrain in using Cragg's Double Hurdle model is challenge of incorporating unobserved heterogeneity into the model. Unobserved differences between farmers are likely to influence transactions costs effects on marketing of farm output. Drawing from the contributions in the literature, we deal with this issue by augmenting Cragg's Double Hurdle model with Correlated Random Effects. This is implemented by adding time-averages of household characteristics into the model. Various specifications of this augmented model have been tried to test the robustness of the results. Details about the implementation of the procedure are provided in the appendix.

The key results are largely consistent with the results obtained in the basic Cragg's model- See Tables (24-26).

3.6 Conclusion

Several papers have documented transactions costs effects on market participation of small-scale farmers in developing countries. These studies have identified transactions costs from the state of community infrastructure relating to market accessibility-distance, roads, support services etc.; and household characteristics relating to search and bargaining skills, ability to process information etc. Results from these studies have shown that transactions costs constrain market participation by driving a wedge between household shadow and market prices thereby lowering incentives to participate as sellers of farm output or buyers of goods for household consumption.

For subsistence farmers, constraints on market participation (especially in selling farm output) results in jointness of production and consumption decisions since lower returns from agricultural activities due to transactions costs in market exchange of farm output decreases households' ability to finance consumption decisions. Responses to these constraints which have been considered in the literature include: non-participation and low intensity conditional on participating in markets to sell farm output; and internalizing food markets by using farm harvest for household consumption. These analyses have often been done separately. We contribute to the literature by examining transactions costs effects on farmers' marketing of farm output and use of farm harvest for household consumption. Rather than focusing on marketing of farm output of a single crop as done in several studies, we construct an index of market participation by first obtaining the proportion of output sold of individual crops produced in a given farming period, and then aggregating it to household level across all crops produced by a given farmer. Similarly, we define the size of internalized food markets using the contribution of farm harvest to the quantity consumed of a given item relative to other sources such as quantity of purchased goods. This is done for all items consumed by a household in a given period and aggregated to household level. With a rich multi-crop definition of market participation, we also examine the heterogeneity of transactions costs effects on market participation between cash crop and non-cash crop farmers and based on differences in diversity of crop portfolio.

We use data from three rounds of the Ethiopia Rural Household Survey (ERHS) to construct a balanced panel of households surveyed between 1999 and 2009. We define market participation and use of farm output for household consumption as a discrete choice of participation or non-participation; and a continuous choice of intensity of participation. We fit Cragg's double hurdle model augmented to control for unobserved heterogeneity using Correlated Random Effects (CRE).

We find statistical evidence that distance to market and major town lowers both farmers' probability of participating as sellers and conditional on participation the volume of farm output sold. Distance to market is assumed to reflect the size of explicit marketing costs such as transportations costs; and implicit costs such as opportunity costs of time spent selling farm output. Distance to major town on the other hand, is assumed to indicate the extent of market integration and access to larger markets with bigger clientèle. Improvements in road conditions and markets appear to have a larger effect on farmers' intensity of participation. Sellers of farm output in communities with such improvements and hence lower transactions costs appear to participate more intensely on average. It is also observed that in addition to community infrastructure such as road conditions, improvements in market infrastructure also have a significant effect (and comparatively larger than the effect of improvements in roads) on the intensity of market participation. These results illustrate the effect of costly exchange as constraints on farmers' marketing of farm output- especially non-cash crop farmers and farmers with less diverse crop portfolio whose discrete choice to participate appears to be constrained by distance to market.

The use of farm harvest for household consumption also appears to be influenced by transactions costs. Similarly to marketing of farm output, the effect of distance to market is much smaller than expected. However, improvements in road conditions and markets significantly lower the use of farm harvest for household consumption perhaps due to increase in incentives to sell farm output or lower costs of participating in markets as buyers of goods for household consumption.

Apart from transactions costs indicators, food prices also appear to have a significant effect on farmers' market participation decisions. Increase in food prices

lower the intensity of farmers' participation as sellers of farm output and increase the size of internalized food markets. This is in line with results from previous studies that food price volatility is often interpreted as a signal to food scarcity in response to which farmers increase their inventory of food stock and thus decrease the volume of marketed surplus.

Policy interventions targeting increased agricultural commercialization which ignore the presence of transactions costs and its effects on farmers' allocation of farm output decisions is likely to be less effective. As highlighted in previous studies, policy actions such as improving road networks and market infrastructure which lower participation costs and increase market integration are likely to significantly increase farmers market participation. These interventions can increase the reliability on markets to meet household food demand and facilitate exchange of farm harvest thereby increasing participation of farmers and buyers of goods for household consumption and sellers of farm output.

In summary, the results indicate that transactions costs such as distance to market and improvements in roads and markets affect both farmers' marketing of farm output and use of farm output for household consumption. The effect on the former has not been examined extensively in the literature. Costly exchange of farm output due to transactions costs creates disincentives for farmers to sell farm output and increases gains from internalized food markets. The results also indicate the jointness of household production and consumption decisions observed through the effect of food prices on market participation decisions.

3.7 Appendix

3.7.1 Description of variables

Table 22: Description of Variables

Variable	Description
Mkt. Participation (seller=1)	A binary variable indicating a farmers' market participation as a seller
hh. sales index	The intensity of market participation measured through a sales index.
use farm harvest (=1)	A binary variable indicating farmers' use of farm harvest for hh. consumption
Prop. of Self-produced Consumed Items	The number of consumed items produced by the household as a proportion of total consumed
Prop. of Qty. obtained from harvest (all items)	The quantity of consumed items produced by the household as a proportion of total quantity consumed averaged for all items consumed by the household.
Prop. of Qty. obtained from harvest	The quantity of consumed items produced by the household as a proportion of total quantity consumed averaged only for items produced and consumed by the household
Hh. head's age	Age of household head
Hh. head (male=1)	Male headed household
Hh. size	Household size
Number of plots	Number of plots used by household
Tropical Livestock Units	A measure of household wealth constructed by allocating weights to various livestock by the household- cattle, horses, ox, etc. See Dercon (????)
IDDIR member (=1)	A binary variable indicating membership of a funeral society
Food price Index (Deviation from avg.)	Food Price Index provided in ERHS
Agric. cooperative (=1)	A binary variable indicating availability of agricultural cooperative in the communit
Agric extension Service (=1)	A binary variable indicating availability of agricultural extension service in the comm
Distance to mkt. (in km)	Distance to market in kilometers
Distance to major town (in km)	Distance to major town in kilometers- A measure of market/community integration
Number of mkts in Community	Number of markets within the community.
better road (=1)	Improvement in access to other towns due to better road network
improved mkt. (=1)	Improvement in access to markets
Choice of mkt. (village mkt=1)	A binary variable for sellers of farm output in village market.
cart owner (=1)	A binary variable for households owning a cart- access to means of transport
Crop diversity Index (Food & cash crops)	An index of crop diversity measuring using the number of food & cash crops produc
Crop diversity Index (Food Crops only)	An index of crop diversity measuring using the number of food crops produced
Cash Crop farmer (=1)	A binary variable for cash crop producers such as coffee

3.7.2 Average Partial Effects for Cragg's Double Model.

The Partial effect of a continuous variable x_j on farmers' discrete marketing decision is computed as follows following Burke (2009):

$$\frac{\partial P\left(y>0|\mathbf{x}\right)}{\partial x_{j}}=\phi\left(\mathbf{x}\beta\right)\bullet\beta_{j} \tag{49}$$

For a binary variable x_j, the partial effect on participation is computed as:

$$P\left(y>0|\mathbf{x}\right)|_{x_j=1}-P\left(y>0|\mathbf{x}\right)|_{x_j=0}=\Phi\left(\mathbf{x}\beta\right)|_{x_j=1}-\Phi\left(\mathbf{x}\beta\right)|_{x_j=0} \tag{50}$$

Similarly, the partial effects on intensity of participation for continuous and binary versions of a variable x_j is computed as:

$$\frac{\partial E\left(s|\mathbf{x},y>0\right)}{\partial x_j}=\beta_j\left\{1-\lambda\left(\mathbf{x}\beta/\sigma\right)\left[\left(\mathbf{x}\beta/\sigma\right)+\lambda\left(\mathbf{x}\beta/\sigma\right)\right]\right\} \tag{51}$$

$$E\left(s|\mathbf{x},y>0\right)|_{x_j=1}-E\left(s|\mathbf{x},y>0\right)|_{x_j=0}=\left[\left(\mathbf{x}\beta\right)+\sigma\lambda\left(\mathbf{x}\beta/\sigma\right)\right]|_{x_j=1}-\left[\left(\mathbf{x}\beta\right)+\sigma\lambda\left(\mathbf{x}\beta/\sigma\right)\right]|_{x_j=0} \tag{52}$$

Where $\mathbf{x}\beta$ is a vector of explanatory variables and their corresponding parameters to be estimated; $\lambda\left(\mathbf{x}\beta/\sigma\right)=\phi\left(\mathbf{x}\beta/\sigma\right)/\Phi\left(\mathbf{x}\beta/\sigma\right)$ is the Inverse Mills Ratio (IMR) and σ-sigma is obtained from maximizing the log-likelihood function defined in the econometric model.

3.7.3 Dealing With Unobserved Heterogeneity

To account for unobserved heterogeneity in the estimation of market participation decisions, the error terms in the structural equations in (38) and (39) are defined following Ricker-Gilbert and Jayne (2009) and Ricker-Gilbert et al. (2011) in their work on the effect of use subsidized fertilizer on demand for commercial fertilizer in Malawi.

$$\epsilon_{it}=c_{i1}+\varphi_{it1} \tag{53}$$

$$\varepsilon_{it}=c_{i2}+\varphi_{it2} \tag{54}$$

where $c_{i1}$and c_{i2} represents time-constant unobserved farmer heterogeneity such as differences in farming ability, risk attitude etc.; and φ_{it1} andφ_{it2} represents periodic unobserved shocks to farmers marketing decisions such as health shocks, changes in household head resulting in changes in marketing ability etc. Independence between the factors which affect farmers' marketing decisions and these unobservable factors (c_{i1},c_{i2}) and $(\varphi_{it1},\varphi_{it2})$ is required to obtain consistent esti-

mates.

To relax the assumption of independence between the covariates and unobserved time-invariant household characteristics which affect marketing decisions: (c_{i1}, c_{i2}), we follow Ricker-Gilbert et al. (2011) in using the Correlated Random Effects (CRE) framework also called the Mundlak-Chamberlain Device (due to Mundlak (1978) and Chamberlain (1984)). Under this framework, time-constant values of time-varying household characteristics such as means or initial values of such covariates are used "as with fixed effects while avoiding the problem of incidental parameters in nonlinear models" (Ricker-Gilbert et al. (2011) p.32). The CRE framework as discussed in Wooldridge (2010) and implemented by Ricker-Gilbert and Jayne (2009) and Ricker-Gilbert et al. (2011) , involves the following definition of the unobserved household heterogeneity in both hurdles:

$$c_{is} = \Psi_s + \beta \bar{X}_{is} + k_{is} \qquad k_{is} \mid X_{is} \sim Normal\left(0, \sigma_k^2\right) \quad s = 1, 2 \tag{55}$$

where $\bar{X}_{is}$ represents the time-averaged household covariates andβs are parameters associated with it. In the context of this chapter, $\bar{X}_{is}$ contains household-means of continuous variables and initial values of discrete variables for each household in the sample across all years.

3.7.4 Estimated Parameters from Cragg's Double Hurdle Model + Correlated Random Effects.

Table 24: Transactions Cost Effects: Cragg's Double Hurdle Model

	Mktn. of Farm output		Use of Farm output for Hh. Cons.	
VARIABLES	Stage 1	Stage 2	Stage 1	Stage 2
Hh. head (male=1)	0.0549	0.0406*	0.228***	-0.00615
	(0.0661)	(0.0242)	(0.0780)	(0.0105)
Hh. head's age	-0.000603	0.000808	0.000993	0.000120
	(0.00200)	(0.000751)	(0.00258)	(0.000308)
Hh. size	-0.0164	-0.00362	-0.0145	-0.000903
	(0.0220)	(0.00886)	(0.0289)	(0.00394)
Number of plots	0.0885***	-0.0400***	0.0444*	-0.00637**
	(0.0197)	(0.00696)	(0.0249)	(0.00278)
Tropical Livestock Units	0.00619	-0.00716*	-0.0128	-0.00143
	(0.0107)	(0.00410)	(0.0115)	(0.00156)
IDDIR member (=1)	0.198**	0.110***	-0.0938	-0.0275*
	(0.0842)	(0.0326)	(0.109)	(0.0144)
Food price Index (Deviation from avg.)	0.233	-0.561***	-1.501***	0.170***
	(0.285)	(0.119)	(0.370)	(0.0503)
Agric. cooperative (=1)	0.302***	-0.0698*	0.156*	0.0808***
	(0.0742)	(0.0365)	(0.0920)	(0.0139)
Distance to mkt. (in km)	-0.0360***	-0.0101*	-0.0607***	0.00608***
	(0.00582)	(0.00602)	(0.00573)	(0.00183)
Distance to major town (in km)	-0.0194***	-0.00710***	0.00123	-0.000956
	(0.00524)	(0.00216)	(0.00602)	(0.000799)
better road (=1)		0.0604*		-0.0563***
		(0.0310)		(0.0120)
improved mkt. (=1)		0.149***		-0.0516***
		(0.0560)		(0.0189)
Agric extension Service (=1)	-0.0844	0.0466	-0.361***	0.0274**
	(0.0987)	(0.0410)	(0.121)	(0.0131)
Number of mkts in Community	-0.0959***	0.0128	0.0120	-0.0222***
	(0.0181)	(0.00823)	(0.0218)	(0.00431)
Choice of mkt. (village mkt=1)		0.108***		-0.0287**
		(0.0307)		(0.0132)
cart owner (=1)		-0.0329		0.00176
		(0.0431)		(0.0159)
Constant	-0.0906	0.242**	0.0391	0.143***
	(0.241)	(0.0960)	(0.270)	(0.0390)
Year Dummies	Yes	Yes	Yes	Yes
Correlated Random Effects	Yes	Yes	Yes	Yes
Observations	2,051	2,051	2,051	2,051
chi2	218.2	218.2	265.0	265.0
ll	-879.1	-879.1	1317	1317

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 25: Heterogeneity of Transactions Cost Effects: Cash Crop vs. Non-Cash Crop Farmers

	Distance to Markets		Improved Roads & mkts.	
VARIABLES	Stage 1	Stage 2	Stage 1	Stage 2
Hh. head (male=1)	0.0455	0.0384	0.0418	0.0369
	(0.0667)	(0.0243)	(0.0667)	(0.0241)
Hh. head's age	-0.000736	0.000805	-0.000663	0.000841
	(0.00203)	(0.000750)	(0.00203)	(0.000748)
Hh. size	-0.00796	-0.00336	-0.00763	-0.00353
	(0.0220)	(0.00881)	(0.0219)	(0.00888)
cash crop farmer(=1)	0.180	0.0498	0.739***	0.106*
	(0.268)	(0.0586)	(0.130)	(0.0572)
Number of plots	0.0792***	-0.0409***	0.0814***	-0.0393***
	(0.0199)	(0.00716)	(0.0200)	(0.00710)
Tropical Livestock Units	0.00380	-0.00760*	0.00389	-0.00734*
	(0.0108)	(0.00416)	(0.0107)	(0.00407)
IDDIR member (=1)	0.107	0.100***	0.0934	0.104***
	(0.0870)	(0.0336)	(0.0865)	(0.0337)
Food price Index (Deviation from avg.)	0.241	-0.549***	0.145	-0.553***
	(0.289)	(0.121)	(0.287)	(0.122)
Agric. cooperative (=1)	0.228***	-0.0779**	0.252***	-0.0845**
	(0.0805)	(0.0375)	(0.0761)	(0.0371)
Distance to mkt. (in km)	-0.0323***	-0.00871	-0.0322***	-0.00863
	(0.00567)	(0.00626)	(0.00554)	(0.00598)
Distance to major town (in km)	-0.0181***	-0.00695***	-0.0156***	-0.00698***
	(0.00540)	(0.00232)	(0.00525)	(0.00216)
Distance to mkt.* Cash crop	0.0996	-0.00430		
	(0.0616)	(0.0124)		
Distance to major town* Cash crop	0.0483*	0.000697		
	(0.0251)	(0.00598)		
better road (=1)		0.0575*		0.0826**
		(0.0309)		(0.0375)
improved mkt. (=1)		0.144***		0.144**
		(0.0552)		(0.0564)
Agric extension Service (=1)	0.0281	0.0541	-0.0318	0.0595
	(0.101)	(0.0442)	(0.0992)	(0.0406)
Number of mkts in Community	-0.103***	0.0104	-0.101***	0.0107
	(0.0184)	(0.00843)	(0.0182)	(0.00833)
Choice of mkt. (village mkt=1)		0.105***		0.106***
		(0.0307)		(0.0305)
cart owner (=1)		-0.0359		-0.0380
		(0.0433)		(0.0431)
better road* Cash Crop				**-0.0968***
				(0.0571)
improved mkt* Cash Crop				**0.00903**
				(0.0502)
Constant	-0.218	0.235**	-0.237	0.219**
	(0.240)	(0.0958)	(0.238)	(0.101)
Year Dummies	Yes	Yes	Yes	Yes
Correlated Random Effects	Yes	Yes	Yes	Yes
Observations	2,051	2,051	2,051	2,051
chi2	231.3	231.3	222.9	222.9
ll	-849.5	-849.5	-852.1	-852.1

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 26: Heterogeneity of Transactions Cost Effects: Diversity of Crop Portfolio

	Distance to Markets		Improved Roads & mkts.	
VARIABLES	Stage 1	Stage 2	Stage 1	Stage 2
Hh. head (male=1)	0.0499	0.0390	0.0478	0.0313
	(0.0660)	(0.0241)	(0.0661)	(0.0242)
Hh. head's age	-0.000868	0.000632	-0.000728	0.000721
	(0.00198)	(0.000738)	(0.00199)	(0.000721)
Hh. size	-0.0159	-0.00352	-0.0151	-0.00468
	(0.0222)	(0.00874)	(0.0219)	(0.00874)
Crop Diversity Index	-0.464	0.0996	0.278	0.576***
	(0.473)	(0.171)	(0.297)	(0.186)
Number of plots	0.0867***	-0.0450***	0.0843***	-0.0431***
	(0.0205)	(0.00713)	(0.0202)	(0.00719)
Tropical Livestock Units	0.00638	-0.00785*	0.00633	-0.00694*
	(0.0108)	(0.00410)	(0.0108)	(0.00406)
IDDIR member (=1)	0.195**	0.0891***	0.181**	0.0927***
	(0.0870)	(0.0319)	(0.0861)	(0.0318)
Food price Index (Deviation from avg.)	0.272	-0.467***	0.261	-0.604***
	(0.293)	(0.124)	(0.289)	(0.134)
Agric. cooperative (=1)	0.299***	-0.0774**	0.294***	-0.0668*
	(0.0764)	(0.0367)	(0.0750)	(0.0358)
Distance to mkt. (in km)	-0.0740***	-0.00808	-0.0346***	-0.00754
	(0.0148)	(0.0107)	(0.00593)	(0.00591)
Distance to major town (in km)	-0.0211**	-0.0137***	-0.0194***	-0.00673***
	(0.0102)	(0.00460)	(0.00524)	(0.00217)
Distance to mkt.* Cash Diversity	0.207***	0.00718		
	(0.0638)	(0.0320)		
Distance to major town* Cash Diversity	0.00686	0.0234		
	(0.0371)	(0.0170)		
better road (=1)		0.0467		0.0607
		(0.0303)		(0.0655)
improved mkt. (=1)		0.133**		0.286***
		(0.0532)		(0.0838)
Agric extension Service (=1)	-0.0517	0.0551	-0.0847	0.0430
	(0.0991)	(0.0412)	(0.0987)	(0.0417)
Number of mkts in Community	-0.0976***	0.0103	-0.0964***	0.0132
	(0.0185)	(0.00810)	(0.0181)	(0.00830)
Choice of mkt. (village mkt=1)		0.115***		0.107***
		(0.0303)		(0.0307)
cart owner (=1)		-0.0347		-0.0367
		(0.0426)		(0.0424)
better road* Crop Diversity				**-0.0763**
				(0.187)
improved mkt* Crop Diversity				**-0.441****
				(0.178)
Constant	0.0788	0.308***	-0.0946	0.123
	(0.270)	(0.105)	(0.241)	(0.115)
Year Dummies	Yes	Yes	Yes	Yes
Correlated Random Effects	Yes	Yes	Yes	Yes
Observations	2,051	2,051	2,051	2,051
chi2	236.0	236.0	222.8	222.8
N_clust	696	696	696	696
ll	-866.6	-866.6	-870.2	-870.2

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4 Persistence of Links in Risk-Sharing Networks: Strategic Consideration versus Social Factors.

Abstract

In this chapter we examine the persistence of links within risk-sharing networks of households in rural Ethiopia. Using two rounds of data collected over a five year period, we identify persistent links as individuals listed in both periods by households as their source of support in times of need. We investigate the extent to which the persistence of links in these networks are driven by strategic or social factors. Under strategic considerations, households are assumed to choose risk-sharing partners to maximize gains from insurance. On the other hand, risk-sharing arrangements between households (especially with family members and close neighbors) may persist overtime due to social factors such as altruism. We consider these explanations in the chapter using attributes of links in repeatedly observed risk-sharing networks in Ethiopia. We find that link attributes such as kinship relations, proximity (both in terms of neighborhood and farming area), connectedness of links and endowments (such as land) significantly influence the persistence of links in risk-sharing networks. Further examination of the persistence of specific links indicate that the effects of these factors differ in magnitude and statistical significance across links with family members and neighbors; as well as based on type of relationship- money-lending and labor sharing links.

Keywords: *risk-sharing networks, informal-insurance, persistent links, utility maximization, social factors, Ethiopia.*

JEL Classification: D10 O12 Q12

4.1 Introduction

The objective of the chapter is to examine the persistence of risk-sharing arrangements between households in rural Ethiopia. Using data on households' network of individuals they rely on for support in times of need, we examine the extent to which the persistence of these relationships overtime is strategically driven to maximize gains from insurance or influenced by social factors such as altruism. We use two rounds of data on individuals a given household relies on for support collected five years apart to identify persistent relationships or links as individuals listed in both periods. Through the attributes of these links (such as differences in endowment, proximity, existence of kinship ties, type of support provided) we investigate the extent to which persistence of risk-sharing links over the five years is influenced by attributes associated with strategic consideration or social factors which oblige households to mutually support each other. We hypothesize that under strategic considerations, households are assumed to choose risk-sharing partners to maximize gains from insurance. Therefore, attributes of links such as wealth, proximity, type of support etc. are important to the household in maintaining risk-sharing arrangements overtime. On the other hand, risk-sharing arrangements between households may persist overtime due to social factors such as altruism where households share kinship or neighborhood. We test this hypothesis using a binary definition of link persistence, to fit a logit model on link level data.

With link level data, risk-sharing networks are defined at household level rather than risk-sharing groups as done in several previous studies. As a result, the heterogeneity of systems of mutual support across households can be captured. Furthermore, by this definition, links which form risk sharing networks are heterogeneous not just in terms of endowments/wealth; but also differences in other attributes across links such as type of mutual support in addition to risk-sharing, social and spatial distances, history of relationship etc. Two unique advantages of this data structure which facilitate our analysis are: the availability of two rounds of data on households' risk-sharing networks; and the availability of various attributes of the links which form these networks. With two rounds of data, it is easier to identify links which persist and also to obtain causal effects of attributes

which influence persistence by using previous link characteristics since they are exogenous to link persistence. With various attributes of links we can consider several definitions of social and strategic factors and also capture the heterogeneity typical in endogenous networks which are absent in exogenous risk-sharing arrangements. Jointly, these features enable us to examine the underlying factors which influence the persistence of links within risk-sharing networks through their characteristics. Furthermore, using information about the type of supported provided by each link within the network, we can examine the persistence of specific links such as kinships, neighbors, labor-sharing and financial links. This is motivated by the need to account for possible differences in the nature of households' objectives across links in forming risk-sharing arrangements.

The chapter draws from various contributions in the literature on informal insurance arrangements. Risk-sharing through mutual support and pooling of resources is a common practice in developing countries where households are exposed to various forms of risks due to household (idiosyncratic) and community (covariate) shocks. These shocks which differ in terms coverage, frequency and persistence range from climatic and health conditions, loss of property and livestock, price shocks among others[33]. The effects of these shocks include lower consumption and income/asset levels in the short and medium-term. Long term effects include poverty-traps affecting quality of nutrition and health outcomes; and also efficiency losses due to low investments in agricultural production, education among others (Dercon (2005)). In addition to the effects of shocks, the state of credit, asset and insurance markets in these communities also affect households' ability to mitigate the effects of shocks ex-ante and ex-post. The presence of credit constraints or poorly developed asset markets or missing formal insurance contracts, affects the effectiveness of risk management and coping strategies developed by households to self-insure. Under these conditions, the accumulation and depletion of assets, use of savings or borrowing, diversification of economic activities such as crop choices and labor allocation may still be inadequate in cushioning the effects of shocks.

[33]For instance, between 1999 and 2004, 52% of surveyed households in rural Ethiopia reported to have experienced drought; 38% reported crop pest or diseases; and 35% reported death of a household member- Pan (2009).

Apart from self-insurance, another strand of the literature considers informal insurance arrangements between households. Under missing insurance markets, households can be insured against shocks through risk-sharing agreements with other households in semi-formal groups or through networks. In risk-sharing groups, informal insurance contracts are designed to share risk through the pooling of resources of participating households whose membership maybe strategically restricted to maximize utility in the form of insurance. A more informal risk-sharing arrangement occurs through networks created by inter-household relationships. Through these networks, social factors such as altruism may implicitly embed systems of mutual support between households within a given community resulting in risk-sharing. Specific forms of these 'contracts' take various forms across several communities such as state contingent transfers, quasi-credit, labor-sharing and other forms of gift exchanges between households sharing kinship, ethnicity/tribe, religious groups, neighborhood, organizational identities or other exogenously identified groups.

This chapter also draws from the contributions of recent papers which have shifted focus from risk-sharing arrangements through exogenous groups to social networks. In developing countries, inter-household interactions among several uses, serve as channels for information sharing and source of mutual support. Through repeated interactions between households due to kinship or neighborhood and shared activities, households share information about various activities and build relationships on which they can rely on for support in times of need. Our focus is on the latter use of these networks formed among households. As systems of mutual support, insurance through these relationships occurs through transfers or other forms of support offered to households facing shocks with the hope that the help will be reciprocated when the need arises. Empirically, examining the extent to which risk-sharing occurs through social networks is challenging. Self-selection by households into networks and possibilities of measurement error in obtaining the full network of households introduces endogeniety concerns. In large communities, a census of households' full network might be both expensive and challenging. In some studies, a sample of the network is obtained by truncating the network size which results in measurement error due to *unobserved social space*. As a result of these concerns, endogenous risk-sharing networks have not until recently been

examined extensively.

Despite these concerns, endogenous risk-sharing arrangements offer an opportunity to investigate interesting aspects of informal insurance contracts since they are defined at household level. Across households, these arrangements are likely to differ in structure at a given period of time and in the underlying mechanism which drives the evolution overtime. In particular, the composition of risk-sharing networks may be strategically chosen by households to maximize gains from insurance or socially influenced by altruism towards relatives and close neighbors. Although in some instances, reasonable hypotheses can be formulated about the underlying mechanism which drives the existence of certain risk-sharing arrangements. For instance, risk-sharing through family/kinship networks are more likely to be based on altruism whereas risk-sharing through semi-formal local associations such as funeral societies in Ethiopia are likely to be based on utility maximization. However, in general, risk-sharing arrangements especially where they are endogenously formed with family members, neighbors, co-members in local associations, etc. are more complex and hence difficult to examine the underlying motivation for their existence. It is perhaps because of this (and data constraints) that several papers on endogenous risk-sharing networks focus on obtaining evidence of insurance.

We contribute to this gap in the literature by using self-reported systems of mutual support between households to construct risk-sharing networks rather than using exogenously identified groups as widely used in previous studies. The links within these networks are reported by households as individuals on whom they rely on for support in times of need. We examine the extent to which the persistence of these links is explained by utility maximization and/or social factors.

We find that link attributes such as kinship relations, spatial distance (especially next-door neighbors), connectedness of links and endowments (such as land) significantly influence the persistence of links in risk-sharing networks. The effects of kinship, proximity and connectedness are robust to the truncation of network size, interdependence in the persistence of links at household level and unobserved household heterogeneity. In the context of informal insurance arrangements, the effect of attributes such as endowments, proximity and shared activities may be

linked to strategic considerations to maximize gains from insurance through commitment and information asymmetry as constraints to efficient risk-sharing. On the other hand, the effect of kinship is can be interpreted as the role of social factors such as altruism in the formation of risk-sharing agreements. Given that the underlying mechanism which derives the formation of risk-sharing arrangements is likely to differ across links, we examine the factors which derive the persistence of specific links such as kinship/family links, links with neighbors, money-lending/financial links and labor-sharing links. We find that the persistence of links with family members is more associated with social factors such as the existence of a link with the household head's father; whereas the persistence of links with non-family neighbors is sensitive to connectedness of the link and shared activities. Similar differences are also observed in the persistence of financial and labor sharing links. The persistence of the latter is influenced by receipt of previous help in addition to connectedness and proximity. The persistence of labor-sharing links on the other hand appears to be sensitive to connectedness and proximity.

4.2 Literature Review

Households in developing countries use various strategies in dealing with shocks they face. Risk of facing these shocks and their possible effect on household welfare create the need to devise various strategies at household level and beyond. These strategies both at household level (self-insurance) and between households (through risk-sharing groups and networks), their use (ex-ante and ex-post) and effectiveness in mitigating the effects of shocks have been the subject of various studies.

4.2.1 Dealing with Risk and The Need for Insurance

Strategies used ex-post (or devised ex-ante) to deal with risk in environments where shocks of various forms are frequent and possibly persistent are an important part of rural household behavior. With incomplete or missing credit and insurance markets and insufficient public safety nets, households' ability to mitigate shocks and achieve consumption smoothing is further constrained. Alternative mechanisms used to cope with risk vary across space and over time yielding a huge body of research-both theoretical and empirical. These studies have focused on identifying strategies used by households to deal with risk; and examining the extent to which such strategies are effective.

In the developing world, various forms of risk-coping strategies are used by households to self-insure against shocks. The effectiveness of these strategies in facilitating household consumption smoothing in the occurrence of a shock has been the subject of several studies. Deaton Angus (1991) and Deaton (1992) examined households' savings and accumulation of assets in environments with incomplete credit markets and households are risk averse and impatient. Similar studies which followed built on this work by using various definitions of assets such as livestock accumulation by households in rural communities of developing countries- See Fafchamps et al. (1998) and (Rosenzweig and Wolpin (1993) for empirical examples). In addition to self-insurance through asset accumulation and depletion, income smoothing strategies through the diversification of economics activities to preserve mean-income; or choosing low-risk-low-return activities to minimize income risk have also been studied. Empirical example include abor allocation (Rosenzweig and Wolpin (1993) , Alderman and Paxson (1994), Reardon (1997),

Kochar (1995, 1999); Moser (1998),Beegle et al. (2003)); diversification of crop choices (Townsend (1995) and Dercon (1996)); low-risk low return crop choices (Morduch (1990)), low return off-farm activities (Dercon and Krishnan (1996)) among others.

Beyond the household and self-insurance strategies, the extent to which risk of exposure to shocks is mitigated through interactions between households been studied. Building on the work by Manski (1993), the role of household networks built through inter-household interactions influence economic outcomes of households have been studied by several papers. Through these networks, channels for information sharing, easing liquidity constraints, risk sharing among others; emerge. The importance of these relationships is indicated by the sensitivity of various household outcomes to household networks. For instance, by relaxing credit constraints through informal loans, or facilitating informal insurance through risk-sharing, or sharing experiences to relax information asymmetry constraints on technology adoption; the effects of shocks and income levels are likely to be affected.

The effectiveness of these strategies in enabling households mitigate the impact of shocks on household welfare is limited. Empirical evidence of households' inability to fully insure themselves against risk has been reported in several papers- Townsend (1995) for Indian villages; Dercon (1996)- Tanzania; Deaton (1997); Porter (2012b) using the ERHS among other studies. Dercon (2000) and Dercon (2005) discussed factors which constraint the use of assets and income smoothing strategies in developing countries. Asset markets are often underdeveloped limiting both access and use of assets to mitigate shocks. These conditions result in covariance between household asset values (especially livestock which is commonly used) and income; introduce risk in asset return and purchasing power of assets especially in communities where assets are a common buffer to shocks- negative shock lowers asset prices due to increased supply by sellers as more households sell their assets to ensure consumption smoothing; and positive shock increases asset prices due to increased demand by buyers as more households invest in accumulating assets. Despite these concerns, some studies such as Dercon (2000) have reported empirical evidence supporting the effectiveness of the use of some assets

such as cattle. However, these assets are very expensive for average households in developing countries. Dercon (2000) also discussed the effect of entry constraints in the form of capital and skills required to diversify economic activities as a means of preserving average household income levels in dealing with income risk.

The state of credit and insurance markets in developing countries which by the standards in developed countries are incomplete and poorly developed [See Besley (1994) for a review] also affects households' ability to mitigate the impact of shocks. Under these market conditions, households are unable to achieve consumption smoothing through borrowing or formal insurance when faced with or (in anticipation of) a shock. These effects are even more pronounced for the rural poor Dercon (2005) (chap. 1). Furthermore, other market conditions such as labor and product markets (which are often thin and less integrated) affect households' ability to cope with risk by diversifying household labor supply or sell household made products intended for income smoothing (Dercon (2005)-chap. 1). These conditions added to variation in rainfall create volatility in crop income through price risk thereby lowering gains from specialization relative to diversifying crop production.

To complement these strategies and enable households better mitigate the effects of shocks, various policy interventions have been formulated targeting vulnerable households in poor communities. Recent examples include rain-index based insurance- [Barnett et al. (2008) among others]. However, since these mechanisms are designed for specific shocks (such as aggregate rainfall shocks), residual risk which is uninsured-referred to as basis risk in the literature; may affect its effectiveness (Dercon et al. (2014)). Other forms of interventions include transfers through government and non-governmental organizations through food for work programs etc. (Dercon and Krishnan (2003)).

In summary, costly self-insurance and public safety nets beyond the budgets of many governments, risk is an inherent part of rural household behavior affecting income and consumption smoothening. In these risky environments with missing and incomplete markets, an understanding of the strategies developed by households to mitigate risk naturally becomes an interesting and active area of research.

Results from these studies are crucial for the development of social protection policies (see Larson et al. (2004) for a review of policies for agricultural markets) which strengthen existing institutions rather than crowd out their effectiveness (especially informal institutions- Attanasio and Rıos-Rull (2000)). Given the results from studies on self-insurance and constraints surrounding its use, alternative strategies have dominated what followed in the literature on households' response to risk. Several papers considered informally devised strategies and the extent to which they are effective in insuring households against risk. These studies have been centered on:

- Confirming whether informal insurance through risk-sharing enable households deal with risk- completely or partially?
- Examining the mechanism through which such arrangements affect household's ability to deal with risk- transfers, informal credit etc.

Below is a selected review of the related literature.

4.2.2 Informal Insurance Through Risk Sharing

In developing countries, informal systems of mutual support are common among households. Households within a given community help each other in times of need through inter-household transfers, informal loans (quasi-credit), labor sharing, share-cropping, gift exchanges among several others. These arrangements maybe implicit among neighboring households, extended families, ethnicities and tribes established on grounds of altruism and reciprocity to facilitate insurance enforced as moral requirement[34]. Risk-sharing may also occur through semi-formally structured associations such as between members of local associations to maximize utility in the form of insurance enforced through set rules. Despite the differences in the underlying mechanisms of various risk-sharing arrangements (see Genicot and Ray (2003)), the ultimate objective is to facilitate cross-sectional consumption smoothing over time (Dercon (2000)). Through risk sharing, households faced with a shock are able to cushion its effects leaving consumption unaffected by changes

[34]See (James (1976) for an earlier work on moral considerations in poor communities

in household income. Furthermore, in developing countries where credit and insurance markets are incomplete or missing, these arrangements can be viewed as informal mechanisms to internalize insurance markets[35].

Having established the motivation for risk-sharing, empirical studies have examined the structure and effectiveness of informal insurance arrangements especially in developing countries. In his seminal work, Townsend (1994) illustrated that through risk sharing, households with identical preferences and facing uncertainty in the form of income shocks maximize expected utility subject to aggregate resource constraints. Through a benevolent social planner (such as a village or family head) Pareto weights are allocated to households participating in risk-sharing arrangements and state-contingent transfers are chosen to maximize household utility subject to aggregate resource constraints. A first best outcome from this arrangement is achieved when households are fully insured against idiosyncratic shocks. This implies that the marginal utility of consumption of households is independent of idiosyncratic (but not covariate) shocks since household consumption is independent of household income. Where risk-sharing is assumed to occur at village level (i.e. all households within the village support each other), full insurance implies that household consumption is only sensitive to the size of income/resources aggregated at village level -*the full risk sharing hypothesis*. Given that transfers are specified to be chosen by the social planner, details of the risk-sharing arrangement such as the number of support/transfers offered to a given household are ignored. The primary focus of the hypothesis is on the extent to which households' are fully insured against idiosyncratic shocks.

To empirically examined the full risk sharing hypothesis, Townsend (1994) argued that under complete insurance, once aggregate income (or more broadly, aggregate resources) is controlled for, changes in household income should not significantly affect household consumption[36]. Put differently, growth in household consumption should be independent of idiosyncratic shocks to household income under full risk

[35]Although much of the literature on informal insurance considers inter-household risk sharing, few others have also considered within household risk sharing- Dercon and Krishnan (2000) examined risk sharing between husbands and wives in Southern Ethiopia.

[36]A modified version of this test is provided in Deaton (1997). He argued that under complete insurance, growth rate of consumption is the same for all households thus cross-sectional variances must be zero.

sharing. This is tested by regressing household consumption on aggregate income (or consumption), household income and indicators of idiosyncratic shocks. In terms of defining risk sharing groups, Townsend (1994) and several other studies that followed, examined the extent of risk sharing at village level (commonly referred to as *village economies*). By this definition, it is implied that risk sharing occurs between *all* households in the same village and thus idiosyncratic shocks are fully insured. Townsend (1994)- Indian villages; Townsend (1995)- Thia Villages; Udry (1994) informal credit between households in Northern Nigeria. Dercon and Krishnan (2000) among several others [See Dercon (2005) for a recent review].[37]

The motivation for defining risk sharing groups at village level is motivated on theoretical grounds. Given that aggregate resources are used to finance transfers to mitigate shocks, larger groups (all else equal) are by definition expected to better insure risk. This is substantiated by the belief that within villages, interactions between neighboring households facilitate reciprocal exchanges of gifts especially in times of need thereby serving as informal insurance arrangements. (Dercon (2005)- chap.2). The results from several studies on full risk sharing indicate that while informal insurance is effective in mitigating idiosyncratic shocks, it is incomplete thereby providing statistical evidence against the full-risk sharing hypothesis-Townsend (1994); Deaton (1997); Ligon et al. (2002).

Statistical evidence against the full-risk sharing hypothesis at village-level raised further interest in understanding the extent to which informal insurance is effective. In light of this, factors responsible for deviation from first best outcome of complete insurance have attracted significant attention the literature. In particular, costs associated with monitoring and enforcement of agreements have been cited as reasons for incomplete insurance. Given that risk sharing arrangements in developing countries are often implicit (without formal contracts or legal institutions to enforce agreements), constraints due to information asymmetry and commitment are likely to influence equilibrium outcomes. In village risk sharing groups, monitoring and enforcement costs are potentially high due to the number of households involved. This may result in opportunistic behavior such as moral

[37]Studies using US data include Mace (1991)- Consumer expenditure; and Cochrane (1991)-income Dynamics.

hazard creating excessive risk taking. Under these conditions, the possibility of full insurance (first best outcome) through these arrangements is constrained by the trade-off between risk sharing and moral hazard. Thus, incomplete insurance (as reported in several studies) becomes second best. These constraints also raise concerns about the stability of risk sharing groups. Under weak enforcement mechanisms, large risk sharing groups may break into smaller coalitions affecting the effectiveness of informal insurance.

These concerns have been formally incorporated into risk sharing models as constraints on efficient risk sharing. On limited commitment, (Ligon et al. (2000, 2002)) among several others that followed] reported a better fit of risk sharing data on a limited commitment model of informal insurance. Typically, these studies use game theoretic approaches in which gains from participation in repeated agreements to share risk are compared with gains from autarkic behavior- the sub-game perfect equilibrium (Attanasio and Rıos-Rull (2000)). More formally, this adds a participation constraint to ensure agreements are self-enforceable (plus the resource constraint) to the maximization problem. Another strand of the literature also considers the extent to which imperfect information constraints full insurance- Ligon et al. (1998) among others. Similarly, concerns about information asymmetries are incorporated by adding an incentive compatibility constraint to imply that participants must find it beneficial to be truthful to the risk sharing model.

Drawing from these contributions, later studies examined the extent of risk-sharing between groups of households within villages (rather than at village level) with concerns about information asymmetry and limited commitment in mind. Given the implicit and informal nature risk-sharing arrangements as substitutes to formal insurance, it is reasonable to expect mutual support to be more effective between some households within a given village. These groups are likely to be smaller and can be exogenously identified on the basis of households sharing common social traits- kinship, ethnicity/tribe, religion or co-members of semi-formal organizations. Restrictions on memberships and/or implicit social norms (such as altruism, reciprocity and guilt/shame) are assumed to enforce agreements and punish deviations from agreements of mutual support within these groups. Similarly, in-

formation asymmetries about the occurrence of shocks are less likely constraint insurance through risk sharing groups. Through repeated interactions due to kinship, shared neighborhood and shared activities overtime, households are better able to observe risk-sharing partners thereby lowering possibilities of information asymmetry. However, constraints due to the imperfect information about household income and enforceability of agreements may have significant bearing on the efficiency of informal insurance.

- Family/kinship ties (Kinnan and Townsend (2012)), tribal/ethnic identities [Grimard (1997); Munshi (2011) and Munshi and Rosenzweig (2016)], neighborhoods- Murgai et al. (2002); Goldstein (2000).
- Udry (1994)- informal credit in the form of state contingent transfers among households in Nigeria; Fafchamps and Lund (1997)- informal loan exchanges and transfers among households in Ethiopia; Grimard (1997)- tribal identities in Ivory Coast;

The results obtained from these studies illustrate that while not all idiosyncratic shocks are fully insured, informally devised insurance mechanisms improve household welfare by cushioning the effects of shocks- *partial risk sharing*. The frequency of shocks of various forms in these environments added to constraints due to enforceability of agreements makes informal insurance insufficient.

4.2.3 Risk-Sharing Networks

An empirical concern in studying informal insurance through risk-sharing arrangements is the need to use appropriate identification and definition of the manner through which risks is shared. Exogenously identified groups as discussed above have been commonly used in the previous studies. However, recent studies in the literature have considered endogenous risk sharing arrangements. This requires an understanding of household interaction beyond a single exogenous group but rather a composition of family, neighborhood and co-member relationships among others. This growing body of research has been characterized by several studies which have attempted to incorporate game theoretic approaches into the

social networks literature to examine issues such as network formation, dynamics and structure- see Jackson et al. (2008). These contributions have been crucial in the growth of the literature on risk-sharing through household networks.

Apart from risk-sharing groups, households can also rely on the set of individuals they interact with- their social network. Through these interactions, insurance is achieved as implicit agreements of mutual support between households. This definition of risk-sharing differs from exogenous risk-sharing groups since it is defined at household level as a network of links representing the various individuals a given household supports and/or relies on for support. As a result, the complex nature of risk-sharing arrangements between households and its heterogeneity across households can be captured.

In addition, through the dynamics in the structure of household networks which can be obtained in repeatedly observed networks can be used to examine the effectiveness of informal insurance through households' ability to mitigate shocks. Changes in network features such as composition and attributes of links can also be used to examine various aspects of risk-sharing arrangements. By observing the composition of a given households' social network at link level, reasonable explanations for the existence of risk-sharing links can be obtained. Similarly, through the features of these links and their changes overtime, reasonable hypotheses can be formulated about possible constraints to risk-sharing such as the possibility of limited commitment by non-family members; or information asymmetry about efforts of distant and new links[38].
However, access to data on social networks with information about links which facilitate insurance and other challenges such as the endogeniety of networks have limited research on these issues. To examine the effectiveness of insurance provided through social networks, knowledge of the structure of the entire network is required. This is often a major constraint since the costs associated with conducting a census of household networks in a given community is often high. In several studies, a sample of the network is obtained by asking households to list a cer-

[38]A set of studies building on the work of Jackson and Wolinsky (1996) have examined the dynamics of social networks through the changes in links and structures of networks overtime. The concept of pair-wise stability where households decisions to make and break links follows utility maximization is common in this literature.

tain number or type of individuals they are linked to. Empirically, this introduces measurement error due to the truncation of network size which biases results on the effects of social networks on economic outcomes. Krishnan and Shaorshadze (2015) compared a village census of social networks with the survey data used in this chapter. They reported two possible sources of measurement error in the surveys: under-reporting of links, and difference between directed and undirected network of relatives in the survey. Therefore the challenge in using survey data to back out the effect of social networks on economic outcomes is complicated by the fact that the measurement error in such data may not be random as found by Krishnan and Shaorshadze (2015). Further examination of this error by comparing census and survey data also showed that links with relatives are significantly more likely to be reported in the survey (i.e. less likely to be censored). To deal with this issue, Advani et al. (2014) propose that information obtained in the survey can be used to predict network structure of households which is then used to back out its effects on household outcomes.

With these limitations in mind, we use data on households' risk-sharing networks in rural Ethiopia provided by the Ethiopia Rural Household Survey (ERHS) to examine the persistence of links within these networks. As risk-sharing links, we examine the extent to which link persistence is influenced by strategic consideration to maximize gains from insurance or social factors such as altruism. In two rounds of the survey collected in 2004 and 2009, households were asked to list and provide the characteristics and type of relationship they have with five individuals they rely on for support. Responses to these questions in both rounds constitute our definition of risk-sharing networks at link-level as oppose to exogenous groups within communities. In light of the concerns highlighted above (especially in terms of the truncation of the network size), we consider these links as an approximation of the household's core network which facilitates risk-sharing. Another advantage of our definition of risk-sharing arrangements is its ability to capture the different relationships through which risk is shared in communities of developing countries-family ties, friends and neighbors, co-members of local associations etc. By constructing a panel of households interviewed in both rounds, we identify persistent links as individuals listed as risk-sharing partners in both years. Using this definition, we examine the factors that drive link persistence using attributes of links

in 2004 and in 2009. The results from the former are interpreted as causal effects whereas the effects from the latter are interpreted as mere correlations due to endogeniety concerns. The analysis of these results is done through the lens of strategic consideration such as maximizing gains from insurance or social factors such as altruism.

As mentioned earlier, econometric concerns such as endogeniety exist in the use of self-reported social networks. In addition, given that the full network structure is not observable, the truncation of the network size has empirical implications. We draw from recent contributions in the literature in dealing with these concerns.

4.3 Methodology

4.3.1 Data & Conceptual Framework

The Ethiopia Rural Household Survey (ERHS) is longitudinal household dataset which is representative of rural Ethiopia. Data collection started in 1989 with follow up rounds in 1994, 1995, 1997, 1999, 2004 and 2009 summing up to 7 rounds. Over the years, the coverage of the survey has been expanded from an initial number of 6 administrative units to 15 across 4 of Ethiopia's 11 regions surveying 1,477 households. See Dercon (2004b) for a detailed discussion of the dataset.

The surveyed households were asked about a wide range of questions including their agricultural activities, consumption and interactions with other households in their communities. We use the two most recent rounds of the dataset (2004 and 2009) in which households were asked their networks. Using this data:

- We combine link level data of households' risk-sharing networks for households surveyed in both periods.
- Persistent links are identified as links reported in both periods.
- At link level, we estimate the factors which influence link persistence using attributes of links in 2004.
- We interpret these effects along the lines of strategic consideration to maximize gains from insurance or social factors such as altruism.

Below a description of risk-sharing networks as obtained in the data and a comparison of attributes of persistent and non-persistent links is presented.

Household Risk-Sharing Networks

We begin by examining the characteristics of household networks among farmers in Rural Ethiopia. This section builds on the work by Dercon et al. (2005) and Hoddinott et al. (2009) by extending the analysis to include an additional round of the survey collected in 2009.
Information about risk-sharing arrangements between households is obtained from household heads' responses to the questions about "...[at most] **5 most important**

people you can rely on in time of need for support both within village or elsewhere". The attributes of these individuals such as their endowments/assets, location, relationship with household head; and type of relationship(s) such as money lending, labor-sharing, sharecropping; and shared activities such as co-membership in local associations are provided by the household head responding to the questions. All the information relating to the risk-sharing agreement between a household and a given link is provided by the household head being interviewed. This includes the number of links reported by a household and the attributes of each link. We interpret individuals listed by households in both rounds as links within risk-sharing networks. It is assumed that insurance contracts through these arrangements take the form of state contingent transfers to insure households against idiosyncratic shocks. Enforcement of agreements is assumed to be facilitated by social norms and quid-pro-quo which is typical in informal systems of mutual support.
We combine network information at link level for households interviewed in both rounds to identify persistent links. From the recent round of data collected in 2009, persistent links are defined as individuals listed by a given household in both 2009 and 2004. We examine the factors which influence link persistence through differences in the characteristics of persistent and non-persistent links as a preliminary step. More on this is provided in the section on the empirical technique.

A couple of striking features about these inter-household relationships can be identified from the data as presented in the summary statistics below. A description of variables is provided in the appendix in table (35). Although the broad architecture of these networks may not have changed significantly between 2004 and 2009 across households as shown in the table, the composition of the networks in terms of the links listed by households are more likely to change overtime. The extent to which these changes are strategically made to maximize gains from insurance or driven by social factors is the main objective of the chapter. In what follows, we discuss the attributes of the links within these networks as summarized by the statistics below with this objective in mind.

Table 27: Summary Statistics of Links in Risk-sharing Networks

	2004		2009	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Network size	4.0	1.384	4.60	0.994
maintained link (=1)*	0.307	0.461	0.29	0.454
proportion of stable links			0.29	0.254
Measure of Link Visibility**	0.06	0.308	0.409	1.15
Number of Oxes	1.441	3.161	1.286	1.927
Number of other People	4.317	9.149	5.824	11.70
Age	42.287	13.856	42.721	13.679
Near plots	0.275	0.447	0.289	0.453
HHs with more land	0.402	0.49	0.385	0.487
HHs with less land	0.344	0.475	0.40	0.488
HHs with the same land	0.252	0.432	0.224	0.417
Number of adult males	1.905	2.002	1.785	1.561
Neighboring members	0.594	0.491	0.670	0.470
Member in Same village	0.277	0.447	0.242	0.428
Member in Different village	0.125	0.331	0.088	0.284
Members with Kinship ties	0.655	0.476	0.694	0.461
Neighbors with Kinship ties	0.55	0.498	0.618	0.486
Members in Same IDDIRR	0.572	0.495	0.575	0.494
Members in Same Mahber	0.213	0.409	0.188	0.391
Members in Same Iqqub	0.07	0.255	0.06	0.238
Share Cropping Relations	0.054	0.227	0.094	0.293
Oxen sharing Relations	0.23	0.421	0.265	0.441
Loan Exchange Relation	0.492	0.5	0.387	0.487
Labor Sharing Relation	0.436	0.496	0.449	0.497
Link supports HH.	0.858	0.349	0.851	0.356
Link supported by HH	0.911	0.284	0.898	0.303
Link Helped by HH	0.796	0.403	0.811	0.392
Head's Father relies on Link	0.391	0.488	0.552	0.497
N	4,780		5,631	

*In 2004= links repeated in 2009; in 2009= links mentioned in 2004

**Calculated as the number of times a link is mentioned by others within the Community

Overall, more links were reported by households in 2009 than in 2004. A total of 4,780 links were reported in 2004 by 1,204 households compared to 5,631 links reported by the same households in 2009. This observation can be interpreted in various ways such as indication of increased integration among households in rural Ethiopia in 2009 relative to 2009; increase need for informal insurance arrangements due to missing insurance markets, the occurrence and/or persistence of more idiosyncratic shocks among others. Other possible explanations beyond the scope of this chapter include macroeconomic or other policy changes (such as agricultural support services) creating increase collaboration between households and expansion of social networks. Comparing links listed by households surveyed in both 2004 and 2009, persistent links represent an average of 29% of all links listed in 2009. The same result is obtained using historical network data in 2004. Despite the differences in the number of links reported in both rounds- on average 30% of links listed in 2004 were re-listed in 2009. At household level, this implies approximately 2 individuals in a given network of 5 risk-sharing partners were maintained over the five-year period.
In addition to this measure of link persistence, the data also indicates that some of these relationships span across generations-almost 40% of links listed in 2004; and 55% of links in 2009 had/have relationships with the household head's father. It can also be observed from the summary of the data that links within these networks are heterogeneous along several dimensions. The characteristics of links in these networks such as age, number of oxes, number of adult males, land endowments and connectedness with other households; the relationship among households both social such as family members and neighbors; and type of mutual support such as money lending, labor sharing etc. vary across links and by extension across households. Through these differences in the attributes of links, we can examine the factors which influence link persistence overtime and interpret these effects through strategic and/or social factors.

Although risk-sharing arrangements (at least in the context of the chapter) are implicit, evidence of insurance through these networks can be identified from attributes of links within the network such as reciprocity, proximity, relative differences in endowments etc. It can be observed from the data that support provided through these networks is highly reciprocal. On average, more than 80% of links

listed in both years provide support to households and are supported by households listing them as risk-sharing partners. Similarly, almost 80% of links are also reported to have received support from the household in the past. Reciprocity is important in these arrangements since in the absence of legal institutions, enforcement of risk-sharing agreements is commonly achieved through quid-pro-quo. Other features such as proximity and differences in endowment such as land are observed. The majority of risk-sharing partners are neighboring household members-representing almost 60% of the total links listed in both rounds. This is followed by other neighboring households within the same village constituting over 20% of links. Apart from spatial proximity, social distance in terms kinship is also common among households sharing risk. Family members represent more than 65% of links in both rounds. Other indicators of proximity such as near plots are also are also captured. Proximity as captured by these attributes is related to the provision of insurance through constraints such as commitment and information asymmetry. Where risk-sharing partners are distant and not socially obliged (as the case might be with non-family members) enforcement of risk-sharing arrangements might be constrained. The relative difference in endowments such as land among households is expected to influence the formation of risk-sharing arrangements. For instance, to maximize gains from insurance, households are likely to rely on households with more land since they are likely to have more influence in society (since land is centrally allocated in Ethiopia) and better insurers. However, the difference in the proportion of links with more land and those with less land than a given household is small. This is perhaps because, where risk is shared with family members and neighbors as shown above, considerations about differences in endowments are likely to be of second order importance.

Other relationships between households (such as labor and oxen sharing, money-lending and sharing cropping relationships; and shared activities such as memberships in local associations) are also likely to reinforce risk-sharing. Labor sharing and money-lending relationships appear to be fairly common among households thereby insuring households against shocks on labor supply and income loss. Through shared memberships, trust can be built and information asymmetry about efforts and shocks can be relaxed thereby making informal insurance more effective.

In general, although network size is truncated at five members per household, the average size in the data is four members. Therefore, even though concerns about the effect of the truncation of network size in examining the effectiveness of informal insurance exist, an average of four members (below the upper limit) provides statistical support that a network size of five might be a reasonable approximation. As an additional control, the number of other people within the household's network is also captured in both rounds. This number varies greatly across households and may serve as alternative measure of household connectedness and also for use as additional information in dealing with the truncation of risk sharing network.

These features (longevity, diversity and proximity of the links) are broadly in line with the theoretical predictions that for social networks to be effective tools for informal insurance, they must ensure trust and lower enforcement and monitoring costs. Other features of these links such as shared activities ranging from money lending, to labor sharing; share cropping and oxen sharing arrangements; and also shared membership in other informal organizations such as *Iddirr* (funeral associations), *Iqqub* (borrowing and lending societies) and *mahabir* (social groups) will also contribute towards strengthening these relationships as systems of mutual support.

In summary, through interactions between neighboring households and/or family members, households are able to devise informal insurance contracts through mutual support based on the principle of reciprocity. We consider the nature of these arrangements in household networks where links are defined as other households/individuals on whom a given household relies on for support. The reciprocal nature of these relationships also contributes to our identification- the individuals a household is connected to may not necessarily be those they share risk with. However, by only focusing on the people they rely on for support and who also rely on them for support (even where the agreements are only implicit), a reasonable approximation of a household's risk sharing network is obtained. Helped received through these links are also largely obtained from neighbors and relatives. These features illustrate the fact that networks in these environments are quite heterogeneous across several dimensions which are ignored in studies where risk-sharing

arrangements are defined as membership in informal organizations or links with neighbors.

Persistent vs. Non-Persistent Links

As a preliminary step to understanding the dynamics in risk sharing networks, we examine differences between persistent and non-persistent links by means of a t-test on the differences in averages. The objective at this stage is to illustrate differences in the attributes of persistent and non-persistent links. As highlighted above, persistent links represent links maintained over a five-year period (i.e. listed in both 2004 and 2009). Non-persistent links on the other hand are links that did not reappear in 2009 from 2004. As an additional step, we also examine differences in the attributes of persistent links and new links listed in 2009 to examine the extent to which differences in persistence of links is influenced by differences in link attributes which are related to strategic consideration or social factors. The results from the t-tests are presented in table (28) below.

The p-values indicate that persistent links appear to be statistically different from non-persistent links across several attributes as indicated by the significance of the differences in averages of several attributes. Significant differences in attributes are observed between maintained links from 2004 to 2009 and new links in 2009. For some of the features of the links, the average differences are small (albeit statistically significant). However, the differences in the averages of other features are relatively large. For instance, maintained links are on average older, more visible and often have nearer plots than new links. Similar pattern is also observed in household visibility/connectedness and endowments where maintained links have on average more land, more adult males and more oxen and also appear to be more connected with other households. These differences are also observed between maintained and new links in terms of the type of relationship that exist between households especially money lending and labor sharing arrangements; shared membership in local associations; and social proximity- kinship and neighborhood.

On the basis of the observations from the data discussed above, the chapter attempts to examine the extent to which maintained links in risk sharing networks are influenced by strategic considerations to maximize utility from insurance or

Table 28: T-Test of Differences in Attributes of Persistence & Non-persistent Links in 2004 & 2009.

	2004 data			2009 Data		
Variable	Persistent Link in09	Non-Persistent Link	p-value	Persistent Link in04	New Link	p-value
Measure of Link Visibility*	0.087	0.048	0.000***	0.502	0.370	0.000***
Age	41.905	42.456	0.203	45.028	41.77	0.000***
Near plots	0.327	0.252	0.000***	0.355	0.262	0.000***
HHs with more land	0.408	0.402	0.719	0.439	0.364	0.000***
HHs with less land	0.324	0.353	0.053*	0.333	0.413	0.000***
HHs with the same land	0.268	0.245	0.088*	0.228	0.223	0.636
Number of Oxes	1.399	1.460	0.537	1.445	1.221	0.000***
Num of adult males	1.813	1.946	0.034**	1.944	1.720	0.000***
Members with Larger hh. size	0.449	0.432	0.299	0.504	0.449	0.000***
Neighboring members	0.664	0.568	0.000***	0.722	0.649	0.000***
Members in Same village	0.251	0.288	0.007***	0.203	0.258	0.000***
Member in Different village	0.086	0.143	0.000***	0.075	0.093	0.032**
Members with Kinship ties	0.701	0.634	0.000***	0.724	0.682	0.002***
Neighbors with Kinship ties	0.627	0.516	0.000***	0.658	0.601	0.000***
Members in Same IDDIRR	0.602	0.559	0.005***	0.628	0.554	0.000***
Members in Same Mahber	0.215	0.212	0.828	0.212	0.178	0.003***
Members in Same Iqqub	0.083	0.064	0.016**	0.072	0.056	0.021**
Share Cropping Relations	0.054	0.055	0.958	0.115	0.086	0.001***
Oxen sharing Relations	0.237	0.227	0.441	0.295	0.252	0.001***
Loan Exchange Relation	0.505	0.486	0.208	0.423	0.373	0.001***
Labor Sharing Relation	0.474	0.419	0.000***	0.502	0.427	0.000***
Member supports HH.	0.879	0.849	0.005***	0.867	0.844	0.027**
Member supported by HH	0.927	0.905	0.013**	0.914	0.891	0.009***
Member Helped by HH	0.823	0.784	0.002***	0.829	0.803	0.024**
Head's Father relies on Link	0.383	0.394	0.490	0.557	0.551	0.675

*** p<0.01, ** p<0.05, * p<0.1

*Calculated as the number of times a link is mentioned by others within the Community

social factors such as altruism.

4.3.2 Theoretical Model

Conceptual Framework

Our context and data bears some resemblance with what is presented in Genicot and Ray (2003). We assume that there are N households in a given community. In the absence of formal insurance and exposure to various forms of shocks (rain variation, health related shocks, rising food prices etc.), households have incentives to internalize missing insurance markets through their relationships and interactions with other households. The formation of these arrangements may be sensitive of households' need for insurance or social factors such as altruism. The differences in the underlying objective of risk-sharing may be reflected in the changes in structure and composition of such arrangements overtime. Genicot and Ray (2003) discussed certain conditions typical in these environments, which affect the formation and changes in risk-sharing groups/networks. Large groups and networks are particularly susceptible to breaking into smaller coalitions overtime thereby affecting the level of insurance provided. Households facing binding constraints in the use of self-insurance strategies against shocks either due to existing market conditions or the prevalence and persistence of shocks, mutual support between households within a community are common options to pool resources with the objective of facilitating insurance. This process involves choosing links (size of group) and transfer schemes (contingent on a given state of nature) to maximize expected utility. The nature of this utility has been examined through: strategic considerations such as the need for insurance; or social factors such as altruism. We examine this distinction through changes in network composition (such as attributes of persistent and severed ties).

To begin, we assume the following about risk-sharing networks in the context of this chapter:

- Links in risk-sharing networks represent individuals/households on whom a given household relies on for support in times of need such as when faced with a shock. We assume that these shocks are largely idiosyncratic in nature such as labor shortage, income loss/credit constraints, food shortage, livestock loss etc. It is also assumed that the links within risk-sharing networks are

independent in a given network since they are not directly linked; but they overlap across households in a given community since two households might share a common risk-sharing partner(s). As a result, a given link is viewed as a coalition formed between two households such that the network is a collection of coalitions formed by the household to share risk.

- To facilitate insurance through social networks, households make two decisions:

  - forming links with other households- this involves determining the links within a household's larger network to share risk with in a given period of time and the evolution of such relationships overtime- changes in the composition of the risk-sharing arrangement overtime.
  - Designing the transfer schemes (contingent on given states of nature) which facilitate insurance.

- These decisions- especially the transfer scheme; is likely to differ across links within a network with heterogeneous links- family members, friends and neighbors, etc. This might be as a result of the fact that the underlying objective for the formation of risk-sharing might differ across links in a network. We consider two of such objectives as discussed in the literature- to maximize gains from insurance and social factors.

With these in mind, we examine the factors which influence persistent links in risk-sharing networks overtime and the extent to which these factors can be interpreted as social and/or strategic factors which drive the formation of these informal arrangements. What follows builds on the work by Agbaglah (2014), Genicot and Ray (2003) and Fitzsimons et al. (2015).

Risk-Sharing Networks

Following Agbaglah (2014) , let households' social network (the individuals it is linked to) by g_i for all i of such households in the community. From these

relationships, households form risk-sharing network I_g which overlap across households. It is further assumed that in any given period of time, with a probability $p(\theta)$, households face a given state of nature $\theta \in \Theta$. For simplicity, we assume that $\theta \in \Theta = \{h, \ell\}$ and $p(\theta) = (\rho, (1-\rho))$ respectively. In each state, an income distribution $y(\theta) = (y^\imath(\theta))_{\imath \in N}$ is realized with $y^\imath(h) > y^\imath(\ell)\ \forall \imath \in N$. The enforcement of agreements to share risk is implicit. Since institutions such as courts may not be available or accessible in rural communities, enforcement of risk-sharing is often facilitated by societal norms which ensure that households facing negative shocks receive transfers; and those deviating from agreements are punished. To account for the possibility of overlapping relationships within a households' network (and hence risk-sharing parters), there are s possible links within the network I_g-$s \in I_g$[39]. Thus in any given period of time, household $\imath$ makes net-transfers $z^\imath_{sh}$ when $\theta = h$; and $z^\imath_{s\ell}$ when $\theta = \ell$ within s for $\imath \in s$ with transfers received entering as positive values and transfers made entering as negative values. Thus in any given time period, household consumption and transfers are represented by the following equations respectively:

$$c^\imath = (\rho y^\imath_h + (1-\rho) y^\imath_\ell) + (z^\imath_h + z^\imath_\ell)$$

$$z^\imath = \sum_{\imath \in s, s \in I_g} (z^\imath_{sh} + z^\imath_{s\ell})$$

On the basis of this setup, households derive utility from consumption and also from the composition of their network (such as altruist tendencies towards relatives, spill-over effects in the form of market information, farming practices, etc.). For this reason household utility comprises of utility from consumption $u(c)$; and gains from the composition of the household network- $f(d_\imath(g))$. We maintain the assumptions made by Agbaglah (2014) about the u and f: $u(.)$ is smooth, strictly concave and increasing; whereas f is smooth and increasing. $d_\imath(g)$ represents the total number of links in i's network. Note that households in autarky only derive utility from consumption since $f(0) = 0$.

The focus of the chapter is to examine the attributes of links which influence

[39]In our setting, s can be thought as a link between household $\imath$ and another household $\jmath$- where $\imath$ reports that it shares risk with $\jmath$. All such links that $\imath$ has out of her network form the risk-sharing network I_g.

the persistence of risk-sharing arrangements between households to understand the underlying objective of forming risk-sharing networks through changes in the composition of the network overtime. Therefore, we assume that the decision by households $\imath$ and $\jmath$ linked through s to severe or maintain risk-sharing ties overtime can be strategically done to maximize gains from insurance or influenced by social factors such as altruism. Let deviation from a set $D \subseteq N$ be defined as when $\imath$ deviates from all $\jmath \in D$ where set D is included in the union of $\imath$'s links-$S^{\imath}$. Following a deviation, the deviant $\imath$ receives a punishment (the severity of which differs both across links and networks and may occur in the form of loss of relationship, trust etc) and is left with a residual network $g_R \subsetneq g$. The difference between g_R and g (in terms of size and composition) is sensitive to the severity of the punishment imposed by the societal norms. In terms of consumption, the deviating household gets $c_D^{\imath}$ and $c_R^{\imath}$ after punishment.

More formally, in the absence of any deviation between periods, households receive utility of the following form with an additional assumption about the functional form of the utility function. We assume that it follows a CRRA with $\delta \in [0, 1]$ as the discount factor. The typical assumption in the literature is that the discount factor is close to unity- high degree of persistence contributes to the effectiveness of risk-sharing arrangements. Furthermore, in the context of this paper, this assumption is motivated by the fact that the choice of maintaining the composition of a network or make adjustments is an intertemporal arbitrage decision which is likely to be affected households' valuation of future utility.[40]

$$U_{\imath}\left(c^{\imath}, g\right) + \frac{\delta}{1-\delta}\left(\rho U_{\imath}\left(c_h^{\imath}, g\right) + (1-\rho)\, U_{\imath}\left(c_{\ell}^{\imath}, g\right)\right) \tag{56}$$

In the case of a deviation, the deviant receives the following discounted utility:

$$U_{\imath}\left(c_D^{\imath}, g\right) + \frac{\delta}{1-\delta}\left(\rho U_{\imath}\left(c_{Rh}^{\imath}, g_R\right) + (1-\rho)\, U_{\imath}\left(c_{R\ell}^{\imath}, g_R\right)\right) \tag{57}$$

Thus the incentive compatibility constraint for networks be immune to deviation and hence maintain their composition (i.e. links forming these networks persisting overtime) takes the following form:

[40] Agbaglah (2014) relaxes this assumption to examine the sensitivity of stability of informal insurance institutions to different degrees of patience.

$$U_\imath\left(c^\imath,g\right)+\frac{\delta}{1-\delta}\left(\rho U_\imath\left(c_h^\imath,g\right)+\left(1-\rho\right)U_\imath\left(c_\ell^\imath,g\right)\right)\geq U_\imath\left(c_D^\imath,g\right)+\frac{\delta}{1-\delta}\left(\rho U_\imath\left(c_{Rh}^\imath,g_R\right)+\left(1-\rho\right)U_\imath\left(c_{R\ell}^\imath,g_R\right)\right) \tag{58}$$

$\forall \imath \in N; \quad D \subsetneq S^\imath; \quad g_R \subset g.$

With this structure and following Agbaglah (2014), changes in network links can be defined as follows. Suppose $\theta_0 \in \Theta$ is the current state of the world; and $\beta \equiv (\theta_0, \imath, D, g_R)$ and $\mathcal{F}$ as the collection of all such tuples. Then I_g is stable if and only if, for all $\beta \in \mathcal{F}$:

$$u_\imath\left(c_D^\imath\left(\theta_0\right)\right)-u_\imath\left(c^\imath\left(\theta_0\right)\right)<\frac{\delta}{1-\delta}\left\{\sum_\theta p\left(\theta\right)\left[u_\imath\left(c^\imath\left(\theta\right)\right)-u_\imath\left(c_R^\imath\left(\theta\right)\right)\right]\right\}+\frac{\delta}{1-\delta}\left\{f\left(d_\imath\left(g\right)\right)-f\left(d_\imath\left(g_R\right)\right)\right\} \tag{59}$$

The equation above indicates the two effects of severing ties or breaking away from risk-sharing agreements- the effect on households' ability to ensure smooth consumption when faced with a shock; and the effect on indirect gains from maintaining relations such as altruist gains in preserving relations.

In the context of this chapter, strategic consideration is indicated by the first component of the RHS of equation (59): i.e. $\frac{\delta}{1-\delta}\left\{\sum_\theta p\left(\theta\right)\left[u_\imath\left(c^\imath\left(\theta\right)\right)-u_\imath\left(c_R^\imath\left(\theta\right)\right)\right]\right\}$; whereas social factors are indicated by the second component of the RHS of equation (59): $\frac{\delta}{1-\delta}\left\{f\left(d_\imath\left(g\right)\right)-f\left(d_\imath\left(g_R\right)\right)\right\}$. With further simplification of the states of the world into two, the first component can be re-written as follows:

$$\frac{\delta}{1-\delta}\left\{\left[\rho u_\imath\left(c_h^\imath\right)+\left(1-\rho\right)u_\imath\left(c_\ell^\imath\right)\right]-\left[\rho u_\imath\left(c_{Rh}^\imath\right)+\left(1-\rho\right)u_\imath\left(c_{R\ell}^\imath\right)\right]\right\}$$

i.e. the discounted difference in utility between the two states of the world following changes in network structure. Genicot and Ray (2003) refers to the difference in the marginal utilities of the two states of the world as the need for insurance. This difference measures the uncertainty associated with facing risk and hence the need to pool resources. This can be formalized as thus: $\frac{u'\left(c_{,}^\ell\right)-u'\left(c_{,}^h\right)}{u'\left(c^h\right)}>\frac{1-\alpha}{\delta\rho(1-\rho^{n-1})}$.

The second component indicates gains other than insurance derived from keeping links overtime. This is particularly important in a risk-sharing network (as oppose to group) where membership is not identified based on common social traits. Rather, these arrangements are often implicit and exist between households who

may be related differently- relatives, neighbors, friends etc. As such, changes in the composition of the network overtime may be sensitive to these differences in relations which may be influenced by social factors- family members may be socially obliged to support each other. Adhering to these social conventions may generate some form of utility captured in the second term of the equation above.

In summary, the persistence of links in risk-sharing networks overtime maybe strategically influenced by household's need for insurance or other gains such as fulfillment of social obligations due to altruism. We consider these two factors in the chapter.

4.3.3 Econometric Model

Equation (59) shows that changes in links of risk-sharing arrangements overtime maybe influenced by two factors: strategic consideration and social factors. Our objective is to examine the extent to which persistent links in risk-sharing networks are explained by these factors. Using two rounds of data on households' networks spaced five years apart, we identify links which are maintained in both rounds and estimate the factors which influence the persistence of links. In doing this, we define persistent links using a binary variable which is expressed as a function of link attributes such as assets, land endowments, history and type of relationship among other features; and estimated using a logit model as illustrated in the equation below: We analyze the effect of these attributes on link persistence through the lens of strategic consideration and social factors as identified in equation (59).

$$B_{ij} = \alpha_0 + \mathbf{d}_j\alpha_1 + \mathbf{x}_i\alpha_2 + \varepsilon_{ij} \tag{60}$$

Where B_{ij} is a binary variable indicating that a link j listed by household i in 2004 is also listed in 2009- ie. persistent link=1 and 0 otherwise; $\mathbf{d}_j$ is a vector of link characteristics; $\mathbf{x}_i$is a vector of household-specific network characteristics and αs are parameters to be estimated.

Link Level Analysis of Persistence

Given that there are two rounds of data, we can examine the persistence of links using attributes of links as reported in 2004 at link level. Therefore, we consider the

estimating equation (60) using round 1 (collected in 2004) network information on persistent and non-persistent links. In using this data, link persistence is expressed as a function of 2004 features of links which can be assumed to exogenous. As a result, a causal interpretation on the effect of link attributes on persistence can be made. Intuitively, the use of this approach is set on the premise that households' decision to maintain a link in 2009 or not is influenced by the attributes of the link in the previous period. We estimate two specifications of equation (60) at link level:

- Using attributes of links to examine link persistence without household fixed effects.
- Unobserved household heterogeneity may affect households' choice of risk-sharing partners and by extension the persistence of links overtime. To minimize this effect, we incorporate household fixed effects for households with multiple links at the expense of a decrease in the number of observations.

Household Level Analysis of the Persistence of Links

The persistence of links within a given risk-sharing network may be interdependent. This implies that a household's decision to maintain a given link between the two periods may be affected by the status of other links. This cannot be captured in the analysis of persistence of links at link level with standard errors clustered at household level. This approach is in line with our definition of links in theoretical model as a relationship between two households one of whom provides the information about the risk-sharing agreement. However, at household level, the decision to maintain a given link may be influenced by the status of other links within the risk-sharing network establishing inter-dependence in the persistence of links overtime. This is likely to occur in an instance where a household chooses to maintain a link because of changes in the arrangement or existence of another link. Due to these concerns, equation (60) is also estimated at household level rather than at link level. This is done by using the number of persistent links as a proportion of network size in 2009 which is examined using network features in 2004 since they are exogenous. This is also done using network information from 2009, but as be-

fore, we interpret these results as correlations due to concerns about endogeniety. In essence, we collapse the network information from link level to household level where attributes of links including persistence are expressed as averages at household level and estimate equation (60) using OLS. Since the dependent variable is bounded between zero and one- where zero implies no links listed in 2004 were re-listed in 2009; and one implies all links listed in 2009 where listed in 2004; we also use a Tobit model with upper and lower bounds. The results indicate that attributes such as kinship and proximity significantly affect the persistence of links.

Testable Hypothesis:

We use this model to examine the extent to which persistent links are driven by maximizing gains from insurance or social factors. As highlighted in the previous section, the need for insurance and social factors such as altruism as factors which influence risk-sharing arrangements can be identified through the effect of link attributes (such as wealth, history and type of relationship, family/kinship ties etc.) on link persistence overtime. More formally, we test the following hypothesis:

- Do links in risk-sharing networks persist overtime because they strengthen insurance for households or because they exist between households who are socially inclined to share risk?

In the first part of the hypothesis, we focus on attributes of links which are related to maximizing gains from informal insurance such as differences in endowments. A significant effect of these factors on link persistence is interpreted as households being strategic in their decisions relating to changes in their risk-sharing networks overtime. The second part of the hypothesis focuses on the role of social factors such as kinship and neighborhood etc. in the persistence of risk-sharing links. We interpret the effects of these factors as the role of altruism and other socially driven factors on the existence of informal insurance arrangements. The table below provides a list of link attributes through which we identify strategic consideration and social factors as considered in examining the persistence of links.

Table 29: Indicators of Strategic Consideration and Social Factors using Link Attributes

Link Characteristics	**Explanation**
Household wealth: Land Endowment and number of oxes.	Differences in land endowments are likely to indicate differences in wealth and influence within the society. Thus maintaining links with more land may be strategically motivated.
Measure of Link Visibility	Links that are popular as indicated by the number of households that cite them are likely to be wealthy or influencing making them socially connected. Maintaining such links overtime is likely to result in gains in insurance.
Number of adult males	Links with more adult males are likely to be more effective in insuring households against shocks on labor supply.
Near plots. & Shared activities	Households can better monitor the activities of links with whom they share faming area and share activities such as memberships in local associations. This is expected to establish trust and lower possibilities of information asymmetry about effort. The possibility that these households are likely to be neighbors and family members of the household cannot be ruled out.
Kinship/Family relation & Neighboring Households	Households may be altruistic towards neighbors and family members and hence be socially obliged to support them in times of need.
Shared relationships	The existence of shared relationships such as labor sharing, oxen-sharing, money-lending, share-cropping etc. among risk-sharing partners is likely to provide insurance against shocks affecting labor supply, income, oxes and farm output. Households are likely to maintain links with these arrangements to ensure they are insured.
Previous exchange of support	Links supported by a given household maybe maintained overtime since risk-sharing through these networks is assumed to be enforced by quid-pro-quo. Similarly, households due to social obligations and reciprocity are likely to maintain links from whom they received support in the past.

Endogeniety Issues

A major limitation in our definition of risk sharing networks is the truncation of the network size and the role of unobserved heterogeneity in the formation of household networks. Maertens and Barrett (2013) argued that truncation of network size may bias estimates of the effect of social networks on economic outcomes. This is likely to be case for households with more links than they are allowed to report. It is reasonable to assume that full networks are only observed for households listing less than the upper limit. In addition, they also argued that this technique of identifying social networks is likely to provide 'strong' (as oppose to 'weak') links (also referred to as the the '*core*' social network in other studies) and prone to unobserved household heterogeneity which affect the likelihood of including or forgetting to include a given link. These issues have significant implication especially in studies on the diffusion and dissemination of information within communities. However, the focus of the chapter is not on the effect of social networks on household outcomes or the effectiveness of informal insurance through risk-sharing networks. The objective of the chapter is to examine the persistence of links between households within these networks and the extent to which they are driven by strategic or social factors. It is reasonable to expect that households are likely to pool resources and share risk with the 'strong' links within its network as oppose to its full network. Furthermore, in eliciting risk-sharing arrangements between households, respondents were asked to list the **five most important** individuals on whom they can rely for support in times of need. This implies that the network being observed is likely to be the households' core network which serves risk-sharing purposes. These links are expected to be a sub-set of households' larger network of households. Theoretically, this is justified by the fact that a trade-off exists between group size and risk taking, thus we believe five is a reasonable approximation[41]. The summary statistics indicated that the average risk-sharing group has four links which implies that the average household in the sample has less than five members, hence five being a reasonable approximation.

In light of these limitations in the network information, we analyze our results with these concerns in mind and interpret the reported links as a representation

[41] Jackson et al. (2012) restricted number of friends of surveyed households to five in their study of informal favor exchanges between households in 75 rural villages in Southern India.

of the households' core risk-sharing network. Thus, these links are interpreted as an approximation of the household's network. By defining the unit of analysis at link level within a household's network (rather than the full network), we identify persistent links since this is the main focus of the chapter. By means of a binary variable, we differentiate persistent and non-persistent links which are expressed as a function of link attributes in 2004 to obtain interpretation of the factors driving link persistence.

4.4 Results

Using the two rounds of data on households' risk-sharing group, we identify persistent links as links listed in both rounds. At link level, we also estimate persistence using the characteristics of persistent and non-persistent individual links with and without household fixed effects to control for unobserved heterogeneity across households. We extent this analysis into sub-samples of links which facilitate specific forms of support between households- such as labor-sharing, money-lending, kinship and neighborhood links. The marginal effects are presented below.

Table 30: Average Marginal Effects from Logit Estimation of Link Persistence

	Basic		**Household F.E**	
Variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Network size	0.0184**	(0.0074)	-	-
Number of other People	0.0014**	(0.0007)	-	-
Measure of Link Visibility*	0.08***	(0.0201)	0.0682***	(0.0265)
Age	-0.0003	(0.0005)	-0.0004	(0.0008)
Near plots	0.0475***	(0.0158)	0.081***	(0.0246)
Land Endowment:				
Less Land=1	-0.0285*	(0.0172)	-0.0267	(0.0263)
About the Same=1	0.0106	(0.0187)	-0.006	(0.0259)
Number of Oxen	-0.0013	(0.0019)	-0.0018	(0.0066)
Number of adult males	-0.0028	(0.004)	0.0071	(0.0065)
Neighbors				
Same village (=1)	-0.0558***	(0.0169)	-0.1107***	(0.0349)
Different village/town(=1)	-0.117***	(0.0229)	-0.1899***	(0.0572)
Kinship Link (=1)	0.0862***	(0.016)	0.0899***	(0.0263)
Members in Same IDDIRR	0.001	(0.0166)	0.001	(0.0303)
Members in Same Mahber	-0.0316*	(0.0189)	-0.0285	(0.0378)
Members in Same Iqqub	0.054**	(0.0276)	0.0005	(0.0574)
Share Cropping Relations	-0.0205	(0.0307)	0.0296	(0.0598)
Oxen sharing Relations	-0.0168	(0.0188)	0.0133	(0.0385)
Loan Exchange Relation	0.0062	(0.016)	0.0703	(0.0482)
Labor Sharing Relation	0.0179	(0.0164)	0.0605	(0.0409)
Wage Work Relation	-0.0216	(0.0324)	-0.1087	(0.0824)
Crop buying Relation	0.0704*	(0.0403)	0.0381	(0.0744)
Other relationship	0.0206	(0.028)	-0.0452	(0.0903)
Link supports HH.	0.0225	(0.0249)	0.1345***	(0.0483)
Link supported by HH	0.0184	(0.0292)	-0.0586	(0.0753)
Link Helped by HH	0.0278	(0.0224)	0.0089	(0.0457)
Head's Father relies on Link	-0.039**	(0.0157)	-0.0069	(0.0397)
Household Fixed Effects			Yes	Yes
Number of observations	4,780		3,353	
R-Squared	0.0264		0.040	

Note: The base category for differences in land is more land; The Base category for neighbors it is next door neighbor.

At household level, network information is constructed by aggregating the characteristics of the individual links within the network and used to examine the factors which influence the proportion of persistent links for each household in the data. This is motivated by the possibility of interdependence in the persistence of links within a given network. Results from the estimation of the persistence of links in risk-sharing networks at household level are presented below.

Table 31: Persistence of Links at Household Level (OLS & Tobit)

	OLS		**Tobit**	
VARIABLES	Prop.Persistent Links	Std. Err	Prop.Persistent Links	Std. Err
Network size	0.0450***	(0.00500)	0.0607***	(0.00755)
Number of other People	0.00126*	(0.000713)	0.00164*	(0.000843)
Measure of Link Visibility	0.0957***	(0.0333)	0.145***	(0.0436)
Avg. Age Links	-0.000576	(0.000690)	-0.00124	(0.00102)
Prop. with Near plots	0.0157	(0.0217)	0.0199	(0.0306)
Prop. with less land	-0.0214	(0.0218)	-0.0287	(0.0308)
Prop. with same land	0.00450	(0.0219)	0.00874	(0.0316)
Number of oxes	0.000194	(0.000515)	0.000179	(0.000821)
Number of adult males	-0.00703	(0.00509)	-0.0135*	(0.00771)
Prop. in Same village	0.0449**	(0.0181)	0.0662***	(0.0255)
Prop. of relatives	0.0963***	(0.0191)	0.140***	(0.0276)
Prop. in same IDDIRR	0.00742	(0.0188)	0.0128	(0.0261)
Prop. in same Mahber	-0.0293	(0.0212)	-0.0409	(0.0294)
Prop. in same Iqqub	0.0528*	(0.0304)	0.0702*	(0.0409)
Prop. with share cropping R'ship	-0.0535*	(0.0293)	-0.0661	(0.0430)
Prop. with oxen sharing R'ship	-0.0267	(0.0203)	-0.0357	(0.0280)
Prop. with money lending r'ship	-0.0102	(0.0160)	-0.0205	(0.0223)
Prop. with labor sharing r'ship	-0.00119	(0.0171)	0.00244	(0.0234)
Prop. with wage work r'ship	-0.0100	(0.0294)	-0.00771	(0.0418)
Prop. with crop buying r'ship	0.111**	(0.0444)	0.142**	(0.0580)
Prop. with other r'ship	0.00283	(0.0277)	-0.0134	(0.0391)
Prop. of links that helped hh	-0.0458*	(0.0268)	-0.0749**	(0.0374)
Prop. of links relying on hh.	0.0289	(0.0261)	0.0424	(0.0387)
Prop. of links helped by hh.	0.0520**	(0.0221)	0.0708**	(0.0326)
Prop. of links on which father relied	-0.0508***	(0.0157)	-0.0657***	(0.0220)
Constant	0.0519	(0.0484)	-0.0617	(0.0719)
Observations	1,204		1,204	
R-squared	0.116		0.109	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Social Factors

Social factors such as kinship ties significantly affect the probability that a

given link is maintained overtime. The average marginal effects using link level data indicate that links with family members are on average 8.6% more likely to be maintained than non-family members. In the specification with household fixed effects, a similar effect is observed albeit slightly larger (8.99%). Compared to the effects of other link attributes, the estimated effect of kinship ties is fairly large. At network level, increase in the number of links with family members as a proportion of network size is positively associated with the number of persistent links as a proportion of network size in both the OLS and Tobit estimated models. All else equal, increase in the number of links with relatives is expected to increase the proportion of persistent links by 9.63% on average.

Given that these arrangements are often implicit and informally structured, it is not surprising that the persistence of links within risk-sharing networks is significantly associated with the existence of kinship between households. Several previous studies including Kinnan and Townsend (2012) have illustrated the role of kinship in facilitating the formation of informal insurance arrangements. It is thus not surprising that links with relatives are more likely to be maintained overtime. In these communities, extended family members provide support to each other in times of need. These arrangements often implicit and enforced through moral obligations and commitment to preserving family ties enable households mitigate the effects of shocks through state-contingent transfers. Jointly, these factors enforce risk-sharing arrangements between family members making such links persistence overtime. On the other hand, households are less likely to be socially obliged to form risk-sharing arrangements with non-family members. Where these arrangements exist, their persistence is likely to be constrained by enforcement and monitoring costs associated with such links to ensure help is reciprocated when needed.

Strategic Consideration

To examine the extent to which strategic considerations to maximize gains from insurance affect the persistence of links, we consider link features such as land endowment and connectedness of links. In terms of differences in land endowments between the household and its links, links with less land compared to the household are less likely to be maintained relative to links with more land than the

household. The effect is negative with an estimated average marginal effect of approximately 3% decrease in the probability of persistence in both specifications using link level data. However in the specification with household fixed effects, the effect is statistically insignificant. On the other hand, differences in land endowment of links with about the same land with the household and links with more land than the household do not significantly affect persistence. The same effect is observed in the household level analysis- households with more links with less land on average have fewer persistent links. Therefore in general, in terms of land endowments, links with less land than the household relying on her for support are less likely to be maintained overtime. Although land is centrally allocated in Ethiopia, households' land endowment is assumed to be an indicator of influence in society in addition to its typical role as an indicator of household wealth. Thus, all else equal, households with more land are expected to be more reliable in providing support when in need thereby increasing incentives to maintain them overtime.

The effect of a link's connectedness or 'visibility' on persistence can also be examined through the context of strategic consideration. We approximate the connectedness of a link using the number of other individuals apart from the household but within the sample who mention the link as part of their risk-sharing network. It is assumed that through this measure, more connected or prominent individuals within the community will be cited more often by other households. It is observed that the marginal effect of increased connectedness on the probability of link persistence is estimated to an increase of 8%. Adding household fixed effects, the marginal effect decreases slightly to 6.8% but remains statistically significant. At household level, networks with more connected links have a higher proportion of persistence. Using the OLS estimated model, increase in the connectedness of links with a given network, is expected to increase the proportion of persistent links by 9.57% on average.

The effect of link connectedness on informal insurance can be analyzed through spill-over gains from friends of friends'. By sharing risk with individuals who are well-known or better connected within the society, households are likely to be better supported directly or indirectly through the network and/or influence of such individuals. In anticipation of these gains, households have incentives to maintain highly connected individuals within their network to maximize gains from insur-

ance.

Differences in distance to link or proximity also affect persistence overtime. We examine the role of spatial distance through different categories of neighbors: (next-door) neighboring households, co-villagers and links in neighboring villages/towns. Relative to links with next-door neighbors, co-villagers and links in neighboring villages are significantly less likely to be maintained overtime. The probability of preserving a link with a co-villager is on average 5.6% less likely when compared to a link with a next-door neighbor. Similarly, links between households in neighboring villages are on average 11.7% less likely to be preserved than links between next-door neighbors. The effects are even larger when household fixed effects are considered. The average marginal effects increase in magnitude to 11.1% and 18.99% respectively. Similar results are also observed in another measure of proximity-nearness of plots. On average, links between households with neighboring farming areas are on average 4.8% more likely to be maintained overtime. Using the aggregated network information at household level to control for inter-dependence in the persistence of links shows similar results. In the OLS specification, it is observed that an increase in the number of links within the village increases the proportion of persistent links in the network by 4.5% on average. Similar results are observed in the tobit model.
The effect of proximity of links on informal insurance can be examined in two folds. On one hand, nearer links (especially under this informal setting) are likely to be family members and thus are maintained overtime for altruistic reasons. On the other hand, risk-sharing with nearer links is less likely to be constrained by information asymmetry about efforts and income. As a result, maintaining links with neighboring households relative to other co-villagers and links in neighboring communities maximizes gains from insurance. We examine this distinction between neighbor and family members in the next section on persistence of specific links. These results provide further empirical evidence that village risk-sharing arrangements as previously studied in the literature may not provide full insurance (See Townsend (1994)). To facilitate efficient risk-sharing, households are likely to form these arrangements at lower levels within the village-through groups and networks.

The effect of other link attributes such as shared membership in local associations

and other forms of support or relationship between households on link persistence are mixed. In both the link and household level analysis, it is observed that shared membership in borrowing and lending societies (Iqqub) and funeral societies (IDDIRR) are associated with increased likelihood of persistence although the effect of the latter is small and statistically insignificant. On the other hand, links in the same social group (Mahber) with the household are less likely to be preserved overtime. However, this effect is only significant in the link level analysis without household fixed effects. The persistence of links from Iqqubs and IDDIRRs is perhaps driven by the increased interaction between households through these groups formed to provide insurance against risk due to income loss and funeral costs respectively. Through meetings and other group activities, the bond between members increases yielding spill-over gains in the form of mutual support and trust which translates into risk-sharing beyond the group- at a more inter-household level. As a result of these gains, households may find it strategically beneficial to preserve such links overtime.

In general, while indicators of strategic considerations appear to significantly affect the persistence of links in risk-sharing networks, the role of social factors cannot be ruled out. The magnitude of the effect of kinship relative to other factors on link persistence illustrates the extent to which social factors drives the formation of risk-sharing arrangements. However, other attributes of links such as their wealth and influence, proximity and connectedness also affect the dynamics of these informal arrangements.

4.4.1 Heterogeneity in the Persistence of Links

The previous section, does not take into account the possibility of heterogeneity in the underlying mechanism which drives the formation of risk-sharing arrangements across links. To achieve insurance through risk-sharing, households can strategically choose risk-sharing partners and/or altruistically rely on family members within their networks. The extent to which these mechanisms are observed in risk-sharing arrangements is likely to differ across links in endogenously defined risk-sharing networks. In general, it is reasonable to expect that these links facilitate the exchange of various kinds of support between households which are in principle insurance mechnisms. Given that we defined a household's risk-sharing

network as a collection of coalitions formed with individual households, it is reasonable to expect that the mechanism which drive the formation of risk-sharing is heterogeneous across links which represent the coalitions. These differences may not be easily identified in the model specified above. In light of these concerns, we examine the persistence of specific links such as:

- Family/kinship links;
- Links with neighbors;
- Labor sharing relationships;
- Financial/money-lending relationships.

by estimating equation (60) for each category of links. A similar approach (at least conceptually) is implemented by Jackson et al. (2012) in examining various forms of favor exchanges between households in rural India.

Testable Hypothesis

- We expect that the persistence of links with family members is more likely to be influenced by social factors. We compare this with the persistence of links with neighbors which is expected to be more sensitive to strategic considerations.
- Similarly, the persistence of links for labor sharing is likely to be influenced by strategic considerations such as proximity whereas the persistence of financial links is more likely to be sensitive to strategic considerations such as wealth and trust.
- In general, links with family members and neighbors are likely to be more sensitive to social factors whereas links which facilitate labor sharing or money lending are likely to be more associated with strengthening insurance.

The average marginal effects are presented below:

Table 32: Average Marginal Effects: Persistence of Sub-sample of Links (Kinship & Links with Neighbors)

	Kinship Links				**Links With Neighbors**			
	Basic		**Fixed Effects**		**Basic**		**Fixed Effects**	
Variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Network size	0.014	(0.009)			0.031**	(0.014)		
Number of other People	0	(0.001)			0.003***	(0.001)		
Measure of Link Visibility*	0.074**	(0.031)	0.043	(0.041)	0.077***	(0.025)	0.107**	(0.044)
Age	0	(0.001)	0	(0.001)	-0.001	(0.001)	-0.002	(0.002)
Near plots	0.042**	(0.02)	0.066**	(0.031)	0.08***	(0.023)	0.114**	(0.051)
Land Endowment:								
Less Land=1	-0.035	(0.022)	-0.059*	(0.035)	-0.007	(0.028)	-0.016	(0.052)
About the Same=1	0.006	(0.024)	-0.011	(0.033)	0.018	(0.028)	-0.017	(0.053)
Number of Oxen	0.001	(0.004)	-0.002	(0.009)	-0.002	(0.003)	0.007	(0.017)
Number of adult males	-0.001	(0.005)	0.003	(0.008)	-0.006	(0.006)	0.019	(0.016)
Neighbors								
Same village (=1)	-0.054**	(0.022)	-0.093**	(0.043)				
Different village/town(=1)	-0.135***	(0.027)	-0.181***	(0.07)				
Members in Same IDDIRR	-0.007	(0.022)	0.003	(0.04)	0.029	(0.025)	0.07	(0.066)
Members in Same Mahber	-0.021	(0.024)	-0.031	(0.046)	-0.059**	(0.03)	-0.082	(0.105)
Members in Same Iqqub	0.06*	(0.034)	0.005	(0.087)	0.023	(0.044)	-0.034	(0.116)
Share Cropping Relations	-0.032	(0.023)	0.024	(0.048)	0.024	(0.03)	-0.034	(0.102)
Oxen sharing Relations	0.015	(0.02)	0.088	(0.057)	-0.011	(0.025)	-0.033	(0.13)
Loan Exchange Relation	0	(0.021)	0.101*	(0.053)	0.051**	(0.024)	0.002	(0.104)
Labor Sharing Relation	0.009	(0.037)	0.042	(0.078)	-0.101*	(0.054)	0.126	(0.17)
Wage Work Relation	-0.05	(0.041)	-0.138	(0.123)	0.037	(0.049)	-0.248	(0.183)
Crop buying Relation	0.02	(0.049)	-0.064	(0.109)	0.163***	(0.056)	0.076	(0.152)
Other relationship	-0.036	(0.039)	-0.075	(0.115)	0.114***	(0.036)	-0.411	(0.26)
Link supports HH.	0.01	(0.033)	0.159**	(0.069)	0.033	(0.036)	0.161	(0.101)
Link supported by HH	0.027	(0.041)	-0.079	(0.1)	0.002	(0.038)	-0.036	(0.175)
Link Helped by HH	0.042	(0.027)	0.074	(0.065)	0.014	(0.036)	-0.15	(0.099)
Head's Father relies on Link	-0.022	(0.019)	-0.039	(0.053)	-0.09***	(0.028)	0.044	(0.102)
Number of observations	3,1319		1,984		1,641		881	
R-Squared	0.020		0.0457		0.0499		0.0440	

Kinship Links

A key result from the analysis of link persistence using both household and link level network data is that links with family members or kinsmen are highly persistent relative to links with non-family members. However, with network information on the various attributes of links available at link level, the heterogeneity of persistence across a sub-sample of links (such as family members) can be examined. We investigate why kinship links are highly persistent through the effect of other attributes of kinship links on their persistence. The estimated marginal effects indicate that the effect of land, ox and labor endowments on the persistence of links with family members is not statistically significant. Although these factors have been found to affect other links perhaps due to their effect on maximizing gains from insurance, their effect on the persistence of family links is statistically insignificant. However, proximity of family links (both in terms of neighborhood and farming area) significantly increases their persistence as observed in both specifications with and without household fixed effects. In particular, links with family members in the same village and in other villages/towns are less likely to persist than links with next-door neighboring family members by 9.3% and 18.1% respectively. Similar albeit smaller effects are observed in the basic specification without household fixed effects-5.4% and 13.5% respectively. Also, shared farming area with a family member on whom a given household relies on for support increases the probability of persistence by 6.6% (or 4.2% in the benchmark specification) on average. Other effects such as the connectedness of the link are also associated with increasing the probability of persistence of links with family members by 7.4%. However, this effect is only statistically significant in the absence of household fixed effects.

Therefore, while links with family members are likely to persist overtime due to altruism (since household characteristics such as endowments of land, ox and labor are statistically insignificant), the proximity of these links (in terms of neighborhood and farming area) are also positively associated with being preserved overtime. Thus among risk-sharing arrangements with family members, those nearer to the household are likely to be more persistent. The effect of proximity is likely to occur due to the fact these arrangements often exist in closely knitted societies

where extended families form villages and thus rely on each other for support. The result that households are likely to rely on individuals they share kinship ties with and that such relationships are highly persistent overtime is in line with the previous studies that these implicit systems of support are often established among family members since they are often socially obliged to support each other in times of need.

These results also illustrate the effect of diversity in the composition of risk-sharing networks and the overlapping characteristics of links within these networks. By jointly considering these factors, the underlying mechanisms which drive the persistence of risk-sharing arrangements overtime can be understood. Although the ultimate objective of risk-sharing is to achieve insurance, to the individual households, the role of each link towards this goal might differ based on relationship, wealth, proximity among other factors. These factors are often ignored in studies on informal insurance through risk-sharing groups. As a result, the use of endogenous risk-sharing networks provides a significant contribution in this regard- in terms of data and modeling.

Links with Neighbors

Due to the overlapping nature of link attributes in the data, and to avoid repeating the the analysis in the previous sub-section in which we examined the persistence of family links, we differentiate neighbors between family and non-family to be able to examine the differences in the persistence of links with family members and neighbors. In this sub-section we examine risk-sharing among neighbors by focusing on the persistence of links with non-family neighbors. This sub-set of links also represents a substantial proportion of risk-sharing partners in rural Ethiopia. Despite the absence of kinship relations between such neighbors, repeated interactions between these often facilitates mutual support in times of need. The gains from proximity whether in terms of access to insurance or relaxing constraints due to monitoring and enforcement of agreements are expected to be higher among neighboring non-family households who choose to share risk. For these links, it is observed that connectedness of a link and shared relationships significantly affect their persistence. For instance, all else equal, increase in connectedness of a link is expected to increase the persistence of links with non-family neighbors by 7.7% on

average (and up to 10.7% with household fixed effects). Similarly, the existence of money-lending, crop-buying and other relationships are associated with increased probability of persistence by 5.1%, 16.3% and 11.4% respectively. As can be seen the largest effect is observed in links with crop-buying relationships. Surprisingly, the existence of labor sharing relationship has an opposite effect. However, these effects are statistically insignificant in the specification with household fixed effects. Similarly, differences in endowments of land, ox and labor are all statistically insignificant in the persistence of links with neighbors in both specifications. Thus it appears, differences in endowments of land and labor or wealth measured through number of ox do not seem to influence the persistence of links with neighbors.

These relationships indicate the extent to which scale of interactions between neighbors affects households' reliance on their neighbors for support in times of need. An increase in inter-household interactions is likely to strengthen bonds of friendship and trust resulting in mutual support between households (irrespective of differences in endowments). The effectiveness of informal insurance through these relationships may be facilitated by lower monitoring and enforcement costs making concerns about information asymmetry less likely to constrain risk-sharing. Although households may feel obliged by social norms to support neighbors, the persistence of these arrangements is likely to be sensitive to households' ability to monitor the efforts and activities of its neighbors and enforceability of quid-pro-quo for efficient risk-sharing. For instance, where links with money-lending and crop-buying relationships exist between neighbors, their persistence is likely to be associated with the trust-worthiness (especially with the repayment of loans) of the borrowing and/or buying household which are built through repeated interactions.

Table 33: Average Marginal Effects: Persistence of Sub-sample of Links (Labor-Sharing & Financial Links)

	Labor Sharing Links				**Money Lending/Financial Links**			
	Basic		**Fixed Effects**		**Basic**		**Fixed Effects**	
Variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Network size	0.007	(0.013)			0.038***	(0.013)		
Number of other People	0.001	(0.001)			0.002*	(0.001)		
Measure of Link Visibility*	0.087***	(0.033)	0.075	(0.046)	0.1***	(0.03)	0.094**	(0.041)
Age	-0.001	(0.001)	-0.002	(0.001)	0.001	(0.001)	0.001	(0.001)
Near plots	0.049**	(0.024)	0.105***	(0.036)	0.043**	(0.022)	0.056*	(0.034)
Land Endowment:								
Less Land=1	-0.007	(0.027)	-0.015	(0.039)	-0.009	(0.023)	0.022	(0.033)
About the Same=1	0.005	(0.03)	-0.016	(0.039)	0.035	(0.026)	0.055	(0.035)
Number of Oxen	-0.002	(0.002)	-0.002	(0.009)	0	(0.002)	0.005	(0.007)
Number of adult males	-0.01	(0.007)	-0.004	(0.011)	-0.019***	(0.006)	-0.003	(0.009)
Neighbors								
Same village (=1)	-0.088***	(0.026)	-0.215***	(0.056)	-0.062***	(0.023)	-0.102*	(0.053)
Different village/town(=1)	-0.06	(0.05)	-0.188*	(0.11)	-0.113***	(0.032)	-0.251***	(0.091)
Kinship Link (=1)	0.059**	(0.024)	0.083**	(0.042)	0.12***	(0.023)	0.088**	(0.039)
Members in Same IDDIRR	0.031	(0.028)	0.033	(0.051)	-0.028	(0.023)	-0.025	(0.04)
Members in Same Mahber	-0.017	(0.026)	0.031	(0.056)	-0.01	(0.024)	-0.018	(0.05)
Members in Same Iqqub	0.061*	(0.035)	-0.038	(0.095)	0.049	(0.036)	-0.022	(0.081)
Share Cropping Relations	-0.014	(0.037)	0	(0.08)	0.049	(0.048)	0.076	(0.075)
Oxen sharing Relations	-0.052**	(0.024)	0.003	(0.055)	-0.051**	(0.024)	-0.07	(0.052)
Labor Sharing Relation					0.032	(0.022)	0.072	(0.058)
Loan Exchange Relation	0.022	(0.024)	0.106	(0.07)				
Wage Work Relation	0.006	(0.051)	-0.132	(0.14)	0.014	(0.057)	0.017	(0.132)
Crop buying Relation	0.063	(0.055)	0.036	(0.111)	0.126**	(0.05)	0.139	(0.128)
Other relationship	-0.033	(0.049)	-0.302	(0.186)	-0.013	(0.075)	-0.032	(0.326)
Link supports HH.	0.021	(0.041)	-0.024	(0.099)	0.035	(0.041)	0.041	(0.091)
Link supported by HH	0.125***	(0.045)	0.161	(0.144)	-0.021	(0.047)	0.004	(0.126)
Link Helped by HH	0.004	(0.039)	-0.075	(0.091)	0.054	(0.034)	0.059	(0.089)
Head's Father relies on Link	-0.062***	(0.024)	0.044	(0.062)	-0.069***	(0.022)	-0.009	(0.056)
Number of observations	2,087		1,442		2,354		1,602	
R-Squared	0.0279		0.0577		0.0453		0.0414	

Labor Sharing Links

Since farming is the major economic activity of these households, the presence of labor sharing relationships can help mitigate shocks to labor supply due to illness or death of family members, among other sources of labor shortage. The persistence of links which facilitate labor sharing has been examined through various attributes of links. It is observed that the persistence of labor sharing relationships is largely driven by proximity and kinship ties. Links with near plots, neighboring households and co-members of local association are all individually associated with increase probability of maintaining links with labor sharing relationship. On average, labor sharing relationships are 5.9% more likely to persist among links with kinship ties and 4.9% more likely to persistent when established with links whose plots are near the household's. With household fixed effects, the estimated marginal effects are larger and still statistically significant- 8.3% and 10.5% respectively. The connectedness of these links also increases the probability of persistence by 8.7% on average.
Also, differences in the proximity of links within networks across households significantly affect the persistence of links which facilitate labor-sharing between households. Relative to neighboring households, labor-sharing with co-villagers and links in nearby villages/towns are 21.5% and 18.8% less likely to maintained overtime. However, the effect of the latter is statistically insignificant in the specification without household fixed effects. Also co-members of local associations such as savings associations (Iqqub) are 6.1% more likely to be maintained.

The role of proximity on the persistence of links with labor sharing relationships is perhaps driven by efficiency reasons. For labor sharing links to be effective, they need to be established with reliable individuals such as family members and within reach such as neighboring households; especially where the risk of labor shortage cannot be anticipated with reasonable certainty. As a result, to maximize gains from labor sharing arrangements as insurance mechanisms, the proximity of links in terms of plots, household and shared activity is likely to play an important role.

Money Lending/Financial Links

In the absence of formal credit markets, money lending relationships enable

households to mitigate income shocks by providing quasi-credit. It is observed that the persistence of these financial links are driven by kinship, connectedness, proximity, and existence of a crop buying/selling relationship. Among family members, money lending relationships are on average 12% more likely to be maintained overtime- a smaller effect of 8.8% is observed with household fixed effects. Given that kinship is closely linked with proximity, it is also observed that relative to money-lending relationships with next-door neighbors, such links with other households within the same village and in neighboring villages/towns are significantly less likely to be maintained by 6.2% and 11.3% respectively. The effects are much larger in the specification with household fixed effects estimated at 10.2% and 25.1% respectively. Another indicator of proximity- near farming plots is also positively associated with increased persistence of money lending links.
Another feature of links which strengthens the persistence of links with money-lending relationship is the presence of a crop buying/selling relationship. On average, the presence of such relationship increases the probability of maintaining links with money lending relationship by 12.6% all else equal.

These factors can be interpreted as the role of reliability and accessibility in the effectiveness of financial links. As highlighted before, links with family members are particularly reliable in providing quasi-credit. This has been documented in previous studies such as Udry (1994). The effectiveness of kinship networks in providing credit is perhaps due to altruism implicit in such relationships. Similarly, the effect of proximity and crop buying/selling relationships indicates the role repeated interactions between households in these informal arrangements. This strengthens trust, indicates financial ability and reliability of financial links in providing support when needed. Thus, to maximize gains from insurance through money lending relationships, households maintain links with neighboring households and those who have previously purchased or sold crop output, or family members who facilitate quasi-credit.

Therefore in summary, the results presented in this section illustrate the heterogeneity in the persistence of specific links within risk-sharing networks. Through these analyses it is observed that kinship links play a particularly important role in risk-sharing. This is perhaps because these informal insurance arrangements

are largely built on altruism typical in relationships between family members and close neighbors. Another interesting result is the fact that differences in endowment such as land and ox are typically insignificant (on statistical grounds) once we consider sub-sets of links within risk-sharing arrangements do not appear to influence the persistence of links. This may be attributed to the possibility that the implied arrangement (in the case of labor-sharing and money-lending) or type of relationship (in the case of links with family members and neighbors) are given first order importance in the persistence of links as oppose to differences in endowments. Furthermore, it is equally possible that these insurance schemes may occur in the form of moral support rather than state-contingent transfers. As such, relative differences in endowments may have a lesser effect than anticipated.

4.5 Robustness Test

In this section, we examine the robustness of the results presented above to the truncation of the network size. Since households were asked to list at most five individuals they rely on for support, our estimation of the factors which influence the persistence of links is likely to be biased for households with more than five individuals. For households listing less than five individuals, it is reasonable to assume that the full risk-sharing network of these households is captured. We examine whether the results are sensitive to these differences in network size due to truncation by estimating two separate specifications of link persistence with and without household fixed effects. In the first specification, we examine the persistence of links for households with less than five links- i.e. with full risk-sharing network. In the second specification, we examine the persistence of links for households listing up to five risk-sharing links.

As can be seen below, some of the effects are consistent across both specifications (except for the specification for households with less than five members estimated with household fixed effects perhaps due to loss of observations to degrees of freedom resulting in a much smaller sample size). In particular, indicators of social factors such as proximity of a link (both in terms of neighborhood or farming area) and existence of kinship ties influence link persistence. Other factors such as the connectedness of a link (which is associated with strategic consideration) also increase the probability of a link being persist in both specifications.

Table 34: Robustness of Persistence of Links to Differences in Network Size due to Truncation

	Less than 5 Members				**5 Members**			
	Basic		**Fixed Effects**		**Basic**		**Fixed Effects**	
Variable	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**	**dy/dx**	**Std. Err**
Network size	-0.001	(0.015)			0***			
Number of other People	0.002	(0.003)			0.001*	(0.001)		
Measure of Link Visibility*	0.113**	(0.054)	0.064	(0.088)	0.072***	(0.021)	0.065**	(0.026)
Age	-0.001	(0.001)	0	(0.002)	0	(0.001)	0	(0.001)
Near plots	0.017	(0.032)	0.107*	(0.063)	0.061***	(0.018)	0.069***	(0.025)
Land Endowment:								
Less Land=1	-0.043	(0.032)	-0.028	(0.068)	-0.021	(0.02)	-0.021	(0.026)
About the Same=1	0.027	(0.033)	0.001	(0.061)	0.005	(0.022)	-0.003	(0.026)
Number of Oxen	0	(0.004)	0.035	(0.024)	-0.002	(0.002)	-0.005	(0.007)
Number of adult males	0.003	(0.006)	0.011	(0.012)	-0.005	(0.005)	0.006	(0.007)
Neighbors								
Same village (=1)	-0.038	(0.033)	-0.092	(0.09)	-0.061***	(0.02)	-0.095***	(0.037)
Different village/town(=1)	-0.109***	(0.039)	-0.001	(0.107)	-0.12***	(0.028)	-0.222***	(0.067)
Kinship Link (=1)	0.111***	(0.032)	0.063	(0.062)	0.079***	(0.019)	0.086***	(0.028)
Members in Same IDDIRR	-0.041	(0.031)	0.025	(0.083)	0.016	(0.02)	0.002	(0.029)
Members in Same Mahber	0.003	(0.035)	0.081	(0.102)	-0.04*	(0.022)	-0.043	(0.038)
Members in Same Iqqub	0.028	(0.043)	0.04	(0.13)	0.063*	(0.033)	-0.018	(0.058)
Share Cropping Relations	-0.071	(0.058)	0.033	(0.154)	-0.01	(0.036)	0.048	(0.06)
Oxen sharing Relations	-0.033	(0.035)	-0.039	(0.094)	-0.013	(0.022)	0.026	(0.038)
Loan Exchange Relation	-0.007	(0.029)	-0.069	(0.124)	0.016	(0.019)	0.088*	(0.049)
Labor Sharing Relation	0.024	(0.029)	0.032	(0.113)	0.013	(0.019)	0.059	(0.04)
Wage Work Relation	0.015	(0.043)	-0.176	(0.183)	-0.039	(0.042)	-0.077	(0.085)
Crop buying Relation	0.054	(0.054)	-0.067	(0.208)	0.077	(0.054)	0.054	(0.073)
Other relationship	-0.033	(0.06)	-0.111	(0.185)	0.035	(0.032)	-0.016	(0.093)
Link supports HH.	0.04	(0.049)	0.054	(0.141)	0.018	(0.029)	0.129***	(0.049)
Link supported by HH	0.06	(0.055)	-0.188	(0.173)	0.002	(0.036)	0.015	(0.077)
Link Helped by HH	-0.014	(0.043)	0.266**	(0.133)	0.043*	(0.026)	-0.035	(0.046)
Head's Father relies on Link	0.026	(0.028)	-0.079	(0.098)	-0.061***	(0.018)	0.013	(0.039)
Household Fixed Effects			Yes				Yes	
Number of observations	1,153		568		3,622		2,780	
R-Squared	0.0358		0.0651		0.0271		0.0445	

4.6 Conclusion

Risk is inherent in the livelihood of rural households in developing countries. Exposure to adverse climate and health conditions, loss of property and livestock, food price shocks among others affect household welfare. In the absence of formal insurance and credit markets in these communities, farmers can internalize such markets through risk-sharing. This involves the pooling of resources of family members or relatives, friends, or members of semi-formal associations to explicitly share risk (such as funeral societies in Ethiopia) or implicitly provide mutual support (as in family networks). Despite the differences in the underlying mechanism, these arrangements share a common objective of providing insurance. Enforcement of agreements to share risk is often achieved through various mechanisms such as quid-pro-quo, social norms or group rules. Empirical studies on the effectiveness of these arrangements report evidence of partial insurance against idiosyncratic shocks but not full insurance.

We contribute to this literature by examining the underlying mechanism which drives the persistence of informal insurance arrangements facilitated by mutual support relationships between households. Using information about household networks, we consider two popular explanations for the existence of links within risk-sharing networks: strategic considerations to maximize gains from insurance; and social factors such as altruism. We examine the role of these factors on the dynamics of risk-sharing networks through the persistence of links and the extent to which the changes in network composition overtime are influenced by utility maximizing behavior or social factors.

We use two rounds of data on various attributes of links in risk-sharing networks of households in rural Ethiopia collected over a five year interval (2004 and 2009). We use this information to identify persistent links as links which are maintained in both rounds by a given household. Through the various attributes of the links in these networks, we investigate the factors which influence persistence of links overtime at household and at link level. The objective of the former is to capture the possibility that the persistence of links may be interdependent within a given network- i.e. a given household's decision to maintain a certain link may be influenced by the persistence of another link. On the other hand, to capture the heterogeneity in the attributes of links within the network, we examine persistence at link level with clustered standard errors at the household level. Using the same approach, we also test our hypothesis on specific sub-sets of links such as kinships, neighbors, labor-sharing and money lending relationships to account for possible heterogeneity in the persistence of various links within the network.

We find that link attributes such as kinship relations, proximity (especially next-door neighbors), connectedness of links and endowments (such as land) significantly influence the persistence of links in risk-sharing networks. In the context of informal insurance arrangements, these results are in line with both strategic considerations to maximize gains from insurance and social factors such as altruism. The effect of kinship, proximity and connectedness are robust to the truncation of network size, interdependence in the persistence of links at household level and unobserved household heterogeneity. By forming agreements of mutual support with neighbors, relatives, and others with whom households share activities with, monitoring and enforcements costs in risk sharing agreements are lowered thereby making informal insurance more effective. Furthermore, by sharing risk with family members, constraints due to commitment are less likely to be binding since enforcement can be achieved through altruism and other social norms. Similarly, the proximity of links is also likely to lower incentives to shirk and/or misreport earnings since households can effortlessly monitor activities of other households.

We also observe that the underlying mechanisms which drive the persistence of risk-sharing relationships are sensitive to the heterogeneity of links in terms of shared activity and relationship (such as kinship, neighborhood or type of support). While links with family members are likely to persist overtime due to altruism (since household characteristics such as endowments of land, oxes and labor are statistically insignificant), the proximity of these links (in terms of neighborhood and farming area) are also positively associated with being preserved overtime. Comparatively, the persistence of links with neighbors is influenced by connectedness and shared activities. These attributes can be interpreted as indicators of strategic considerations as discussed above suggesting that links with non-family neighbors are often formed with the goal of maximizing gains from insurance. Similar differences are also observed between labor-sharing and money lending/financial links.

4.7 Appendix

4.7.1 Description of Variables

Table 35: Description of Variables

Variable	Description
Network size	The number of individuals listed by household head. Truncated at 5.
maintained link in 2009 (=1)	Binary variable indicating whether a link listed in 2009 was also listed in 2004.
proportion of stable links	At household level, proportion of links listed in 2009 which were listed in 2004.
Measure of Link Visibility	Calculated as the number of times a link is mentioned by others within the Community.
Number of Oxes	Number of oxes owned by link.
Number of other People	Number of other individuals household can rely on for support as reported by household head.
Age	Age of link.
Near plots	Binary variable indicating household and link have plots near each other.
HHs with more land	Binary variable indicating link has more land than the household
HHs with less land	Binary variable indicating link has less land than the household
HHs with the same land	Binary variable indicating link has about the same land than the household
Number of adult males	Number of adult males in link's household
Neighboring members	Link is a next-door neighbor of the household.
Member in Same village	Link is a co-village neighbor of the household.
Member in Different village	Link is a neighbor from a different village/town.
Members with Kinship ties	Link shares kinship ties with the household head.
Neighbors with Kinship ties	Link shares both kinship ties and neighborhood with the household head.
Members in Same IDDIRR	Link is a co-member in a funeral society (IDDIRR)
Members in Same Mahber	Link is a co-member in a social group (Mahber)
Members in Same Iqqub	Link is a co-member in a borrowing and lending society (Iqqub)
Share Cropping Relations	Household has a share-cropping relationship with household head.
Oxen sharing Relations	Household has an oxen-sharing relationship with link.
Loan Exchange Relation	Household has a loan-exchange relationship with link.
Labor Sharing Relation	Household has a labor-sharing relationship with link.
Link supports HH.	Link supports the household in times of need.
Link supported by HH	The household supports the link in times of need.
Link Helped by HH	The link received help from the household in the past.
Head's Father relies on Link	Household head's father relied on link for support in times of need.

5 Conclusion

Several studies have considered various aspects of subsistence farmers who form a substantial share of the population of rural communities in developing countries. Understanding the behavior of farming households as both producers and consumers through observed choices has been a complex task. It is widely documented that the economic environment in these communities has a significant effect on the nature of the relationship between production and consumption decisions of farmers. For instance, the state markets faced by farmers such as the presence of transactions costs to market participation; or incomplete markets such as missing credit or insurance markets; imposes constraints on household decisions. Since farmers are involved in both production and consumption decisions, they have incentives to respond to the constraints on consumption decisions through production choices and/or informal strategies to replace formal markets. As a result of this relationship, separately examining the extent to which observed production and consumption decisions are profit and utility maximizing respectively may not be an appropriate technique to understanding household behavior since it ignores the joint determination of household decisions. Similarly, under such market conditions, strategies devised by households to *'create'* missing markets have important bearing on the understanding of household behavior and the development of appropriate policy to improve the welfare of farming households. These features which are typical of subsistence farmers in developing countries have been the motivation for several studies on the various aspects of household decisions and interactions between households; vis-a-vis market conditions.

The chapters in this thesis consider the decisions of farming households relating to crop choices, marketing of farm output and risk-sharing arrangements. We investigate the extent to which these decisions are influenced by the state of markets faced by farmers. In particular, we examine the extent to which constraints on consumption decisions can be relaxed through production decisions such as the production of food crops and allocation of farm output for household consumption rather than market exchange. We examine this relationship in the first two empirical chapters of the thesis using data on crop choices and allocation of farm output respectively. In the final chapter, we consider risk-sharing through mutual

support between households as informal insurance arrangements under missing insurance markets. We focus on the persistence of these relationships overtime and the extent to which they are driven by strategic factors to maximize gains from insurance or social factors such as altruism.

The results from the various analysis indicate that farmers' choice of crops are sensitive to both indicators of household food demand, risk preferences and indicators of transactions costs to market participation such as distance to market and improvement in community and market infrastructure. These results highlight the importance of market integration and improvements in market and community infrastructure (which lower transactions costs) for subsistence farmers. Similar effects are also observed in the allocation of farm harvest between market exchange and household consumption. These effects are interpreted as farmers' efforts to internalize food markets through crop choices and use of farm harvest for household consumption under binding constraints on household food consumption such as the presence of transactions costs or missing insurance markets. Under these conditions, farmers derive higher utility from balancing household food consumption through farm output rather than market purchases. As a result, jointness in household decisions occurs since farmers produce food crops to reduce reliance on food markets in satisfying household consumption.

In terms of informal insurance arrangements through mutual support between households, we found that link attributes such as kinship relations, proximity (both in terms of neighborhood and farming area), connectedness of links and endowments (such as land) significantly influence the persistence of links in risk-sharing networks. Further examination of the persistence of specific links indicate that the effects of these factors differ in magnitude and statistical significance across links with family members and neighbors; as well as based on type of relationship-money-lending and labor sharing links. These results highlight the importance of inter-household interactions between family members and close neighbors in insuring households against shocks especially where formal insurance contracts are absent. For these households, the existence and persistence of these relationships is likely to enhance their ability to mitigate shocks of various forms thereby improving welfare.

In summary, these results highlight the complex nature of the relationship between production and consumption decisions of subsistence farmers. Under the market conditions faced by farmers, the possibility of satisfying household consumption through household production occurs both directly (through the use of farm harvest for household consumption) and indirectly (through the use of returns from market exchange of farm output to finance household consumption). In addition, the presence of non-market strategies developed through the interactions between households contributes in relaxing constraints due to missing markets. For these households whose main economic activity is rain-fed farming, uncertainty about rains introduces risk of yield and income loss. However, the ability to share risk by pooling resources among several other informal strategies constitute reasonable substitutes to formal markets.

These results reiterate the importance of understanding the extent to which the decisions of farming households are jointly determined and its sensitivity to existing market conditions. Furthermore, household responses to missing markets or markets for which they face binding participation constraints have significant bearing on both techniques used to examine the behavior of these households and in the design and implementation of appropriate policy. It is imperative for government and other partner institutions such as NGOs to understand the implication of policy interventions such as increase of prices of farm output, provision of subsidies or index insurance without considering the nature of the relationship between production and consumption decisions of a given household, or the existence of informal arrangements to substitute missing markets. As a result of these interventions, negative consequences such as crowding out of gains from effective and existing informal institutions, uneven distribution or reallocation of welfare across farmers, weak response to policy intervention among others. On the other hand, where the development of policy takes into consideration the existence of non-market arrangements and the interdependence of household production and consumption decisions, interventions can be designed to complement these existing arrangements such that farmers' welfare can be improved. This can occur by strengthening the existing informal institutions and improving market conditions to ease the jointness in household decisions thereby enhancing the commercializa-

tion of agriculture for the benefit of farmers, their communities and the economy.

References

Abdulai, A. (2000). Spatial price transmission and asymmetry in the ghanaian maize market. *Journal of Development Economics*, 63(2):327–349.

Abdulai, A. and Regmi, P. P. (2000). Estimating labor supply of farm households under non-separability: empirical evidence from nepal. *Agricultural Economics*, 22(3):309–320.

Advani, A., Malde, B., et al. (2014). Empirical methods for networks data: Social effects, network formation and measurement error. *Unpublished manuscript, University College London.*

Agbaglah, M. (2014). Stability in informal insurances: an approach by networks and overlapping coalitions. *Cahier de Recherche/Working Paper*, 14:10.

Alderman, H. and Paxson, C. (1994). Do the poor insure? a synthesis of the literature on risk and consumption in developing countries. economics in a changing world: Proceedings of the tenth world congress of the international economic association, moscow, volume 4, development, trade and the environment. e. bacha.

Alene, A. D., Manyong, V., Omanya, G., Mignouna, H., Bokanga, M., and Odhiambo, G. (2008). Smallholder market participation under transactions costs: Maize supply and fertilizer demand in kenya. *Food Policy*, 33(4):318–328.

Arslan, A. (2011). Shadow vs. market prices in explaining land allocation: Subsistence maize cultivation in rural mexico. *Food Policy*, 36(5):606–614.

Arslan, A. and Taylor, J. E. (2009). Farmers subjective valuation of subsistence crops: The case of traditional maize in mexico. *American Journal of Agricultural Economics*, 91(4):956–972.

Attanasio, O. and Rıos-Rull, J.-V. (2000). Consumption smoothing in island economies: Can public insurance reduce welfare? *European Economic Review*, 44(7):1225–1258.

Audavidhaya, K., Yoshimi, K., Lau, L. J., and Yotopoulos, P. A. (1984). The comparative statics of the behavior of agricultural households in thailand. *Singapore Economic Review (Singapore).*

Badiane, O. and Shively, G. E. (1998). Spatial integration, transport costs, and the response of local prices to policy changes in ghana. *Journal of Development Economics*, 56(2):411–431.

Bardhan, P. and Udry, C. (1999). *Development Microeconomics.* Oxford University Press, Incorporated.

Bardhan, P. K. (1980). Interlocking factor markets and agrarian development: A review of issues. *Oxford Economic Papers*, 32(1):82–98.

Barnett, B. J., Barrett, C. B., and Skees, J. R. (2008). Poverty traps and index-based risk transfer products. *World Development*, 36(10):1766–1785.

Barnum, H. N. and Squire, L. (1979). An econometric application of the theory of the farm-household. *Journal of Development Economics*, 6(1):79–102.

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern africa. *Food Policy*, 33(4):299–317.

Beegle, K., Dehejia, R. H., and Gatti, R. (2003). Child labor, income shocks, and access to credit. *World Bank Policy Research Working Paper*, (3075).

Bellemare, M. F. and Barrett, C. B. (2006). An ordered tobit model of market participation: Evidence from kenya and ethiopia. *American Journal of Agricultural Economics*, 88(2):324–337.

Benirschka, M. and Binkley, J. K. (1995). Optimal storage and marketing over space and time. *American Journal of Agricultural Economics*, 77(3):512–524.

Benjamin, D. (1992). Household composition, labor markets, and labor demand: testing for separation in agricultural household models. *Econometrica: Journal of the Econometric Society*, pages 287–322.

Besley, T. (1994). How do market failures justify interventions in rural credit markets? *The World Bank Research Observer*, 9(1):27–47.

Bevis, L. E. (2015). Who supplies the nutrients? the puzzle of crop zinc heterogeneity and low-zinc market crops in uganda. *Centre for the Study of African Economies, University of Oxford (United Kingdom) 2015 Conference*.

Binswanger, H. P. and Rosenzweig, M. R. (1986). Behavioural and material determinants of production relations in agriculture. *The Journal of Development Studies*, 22(3):503–539.

Binswanger, H. P. and Sillers, D. A. (1983). Risk aversion and credit constraints in farmers' decision-making: A reinterpretation. *The Journal of Development Studies*, 20(1):5–21.

Braun, J. v., Kennedy, E., et al. (1994). *Agricultural commercialization, economic development, and nutrition.* Johns Hopkins University Press.

Braverman, A. and Stiglitz, J. E. (1982). Sharecropping and the interlinking of agrarian markets. *The American Economic Review*, 72(4):695–715.

Burke, W. J. (2009). Fitting and interpreting cragg's tobit alternative using stata. *Stata Journal*, 9(4):584.

Caillavet, F., Guyomard, H., and Lifran, R. (1994). *Agricultural household modelling and family economics*. Newnes.

Cameron, A. C. (2009). *Microeconometrics using stata*, volume 5. Stata Press College Station, TX.

Chamberlain, G. (1984). Panel data. *Handbook of econometrics*, 2:1247–1318.

Chamberlin, J. and Schmidt, E. (2011). Ethiopian agriculture: A dynamic geographic perspective. Technical report, International Food Policy Research Institute (IFPRI).

Coase, R. H. (1937). The nature of the firm. *economica*, 4(16):386–405.

Cochrane, J. H. (1991). A simple test of consumption insurance. *Journal of political economy*, pages 957–976.

Coyle, B. T., Caillavet, F., Guyomard, H., Lifran, R., et al. (1994). Duality approaches to the specification of agricultural household models. *Agricultural Household Modelling and Family Economics. Amsterdam.*

Cragg, J. G. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica: Journal of the Econometric Society*, pages 829–844.

De Janvry, A., Fafchamps, M., and Sadoulet, E. (1991a). Peasant household behaviour with missing markets: some paradoxes explained. *The Economic Journal*, 101(409):1400–1417.

De Janvry, A., Fafchamps, M., and Sadoulet, E. (1991b). Peasant household behaviour with missing markets: some paradoxes explained. *The Economic Journal*, 101(409):1400–1417.

Deaton, A. (1992). Household saving in ldcs: Credit markets, insurance and welfare. *Scand. J. of Economics*, 94(2):253–273.

Deaton, A. (1997). *The analysis of household surveys: a microeconometric approach to development policy.* World Bank Publications.

Deaton Angus, S. (1991). Saving and liquidity constraints. *Ecomometrica*, 59(5):221–248.

Dercon, S. (1996). Risk, crop choice, and savings: Evidence from tanzania. *Economic development and cultural change*, 44(3):485–513.

Dercon, S. (2000). Income risk, coping strategies and safety nets. Technical report, Centre for the Study of African Economies, University of Oxford.

Dercon, S. (2002). Income risk, coping strategies, and safety nets. *The World Bank Research Observer*, 17(2):141–166.

Dercon, S. (2004a). Growth and shocks: evidence from rural ethiopia. *Journal of Development Economics*, 74(2):309–329.

Dercon, S. (2004b). Growth and shocks: evidence from rural ethiopia. *Journal of Development Economics*, 74(2):309–329.

Dercon, S. (2005). *Insurance against poverty*. Oxford University Press.

Dercon, S., Hill, R. V., Clarke, D., Outes-Leon, I., and Taffesse, A. S. (2014). Offering rainfall insurance to informal insurance groups: Evidence from a field experiment in ethiopia. *Journal of Development Economics*, 106:132–143.

Dercon, S., Hoddinott, J., Woldehanna, T., et al. (2005). Shocks and consumption in 15 ethiopian villages, 1999–2004. *Journal of African Economies*, 14(4):559–585.

Dercon, S. and Krishnan, P. (1996). Income portfolios in rural ethiopia and tanzania: choices and constraints. *The Journal of Development Studies*, 32(6):850–875.

Dercon, S. and Krishnan, P. (1998). Changes in poverty in rural ethiopia 1989-1995: measurement, robustness tests and decomposition. *Working Paper Series-Centre for the Study of African Economies, University of Oxford (United Kingdom)*.

Dercon, S. and Krishnan, P. (2000). In sickness and in health: Risk sharing within households in rural ethiopia. *Journal of political Economy*, 108(4):688–727.

Dercon, S. and Krishnan, P. (2003). Risk sharing and public transfers. *The Economic Journal*, 113(486):C86–C94.

Ellis, F. (1992). *Agricultural policies in developing countries*. Cambridge University Press.

Ellis, F. (1993). *Peasant economics: Farm households in agrarian development*, volume 23. Cambridge University Press.

Eswaran, M. and Kotwal, A. (1986). Access to capital and agrarian production organisation. *The Economic Journal*, pages 482–498.

Eswaran, M. and Kotwal, A. (1989). Credit as insurance in agrarian economies. *Journal of Development Economics*, 31(1):37–53.

Fafchamps, M. (1992). Cash crop production, food price volatility, and rural market integration in the third world. *American Journal of Agricultural Economics*, 74(1):90–99.

Fafchamps, M. and Hill, R. V. (2005). Selling at the farmgate or traveling to market. *American Journal of Agricultural Economics*, 87(3):717–734.

Fafchamps, M. and Lund, S. (1997). Risk-sharing networks in rural philippines.

Fafchamps, M., Udry, C., and Czukas, K. (1998). Drought and saving in west africa: are livestock a buffer stock? *Journal of Development economics*, 55(2):273–305.

Feder, G. (1985). The relation between farm size and farm productivity: The role of family labor, supervision and credit constraints. *Journal of development economics*, 18(2):297–313.

Feder, G., Just, R. E., and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change*, pages 255–298.

Finkelshtain, I. and Chalfant, J. A. (1991). Marketed surplus under risk: Do peasants agree with sandmo? *American Journal of Agricultural Economics*, 73(3):557–567.

Fitzsimons, E., Malde, B., Vera-Hernandez, M., et al. (2015). Group size and the efficiency of informal risk sharing. Technical report, Institute for Fiscal Studies.

Garcia, J. and Labeaga, J. M. (1996). Alternative approaches to modelling zero expenditure: An application to spanish demand for tobacco*. *Oxford Bulletin of Economics and Statistics*, 58(3):489–506.

Genicot, G. and Ray, D. (2003). Group formation in risk-sharing arrangements. *The Review of Economic Studies*, 70(1):87–113.

Getnet, K. (2008). From market liberalization to market development: The need for market institutions in ethiopia. *Economic Systems*, 32(3):239–252.

Goetz, S. J. (1992a). A selectivity model of household food marketing behavior in sub-saharan africa. *American Journal of Agricultural Economics*, 74(2):444–452.

Goetz, S. J. (1992b). A selectivity model of household food marketing behavior in sub-saharan africa. *American Journal of Agricultural Economics*, 74(2):444–452.

Goldstein, M. (2000). Chop time, no friends: Risk and intrahousehold insurance in southern ghana.". *Manuscript, London School of Economics*.

Greene, W. (2003). *Econometric Analysis*. Prentice Hall.

Grimard, F. (1997). Household consumption smoothing through ethnic ties: evidence from cote d'ivoire. *Journal of Development Economics*, 53(2):391–422.

Haan, P. and Uhlendorff, A. (2006). Estimation of multinomial logit models with unobserved heterogeneity using maximum simulated likelihood. *Stata Journal*, 6(2):229–245.

Hausman, J. and McFadden, D. (1984). Specification tests for the multinomial logit model. *Econometrica: Journal of the Econometric Society*, pages 1219–1240.

Heckman, J. J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. pages 475–492.

Henning, C. H. and Henningsen, A. (2007). Modeling farm households' price responses in the presence of transaction costs and heterogeneity in labor markets. *American Journal of Agricultural Economics*, 89(3):665–681.

Hirvonen, K. and Hoddinott, J. (2016). Agricultural production and children's diets: Evidence from rural ethiopia. *Agricultural Economics*.

Hobbs, J. E. (1997). Measuring the importance of transaction costs in cattle marketing. *American Journal of Agricultural Economics*, 79(4):1083–1095.

Hoddinott, J., Dercon, S., and Krishnan, P. (2009). Networks and informal mutual support in 15 ethiopian villages. *Institutional Economics Perspectives on African Agricultural Development*, page 273.

Hole, A. R. (2007). Estimating mixed logit models using maximum simulated likelihood. *Stata Journal*, 7(3):388–401.

Holloway, G., Nicholson, C., Delgado, C., Staal, S., and Ehui, S. (2000). Agroindustrialization through institutional innovation transaction costs, cooperatives and milk-market development in the east-african highlands. *Agricultural economics*, 23(3):279–288.

Holloway, G., Nicholson, C., Delgado, C., Staal, S., and Ehui, S. (2004). A revised tobit procedure for mitigating bias in the presence of non-zero censoring with an application to milk-market participation in the ethiopian highlands. *Agricultural Economics*, 31(1):97–106.

Jackson, M. O. et al. (2008). *Social and economic networks*, volume 3. Princeton university press Princeton.

Jackson, M. O., Rodriguez-Barraquer, T., and Tan, X. (2012). Social capital and social quilts: Network patterns of favor exchange. *The American Economic Review*, 102(5):1857–1897.

Jackson, M. O. and Wolinsky, A. (1996). A strategic model of social and economic networks. *Journal of Economic Theory*, 71(1):44–74.

Jacoby, H. et al. (1988). A shadow wage approach to estimating a labor suply model for peasant households: An application to the peruvian sierra. Technical report.

Jacoby, H. G. (1993). Shadow wages and peasant family labour supply: an econometric application to the peruvian sierra. *The Review of Economic Studies*, 60(4):903–921.

James, C. S. (1976). The moral economy of the peasant. *Rebellion and Subsistence in Southeast Asia*.

Janvry, A. and Sadoulet, E. (2006). *Progress in the Modeling of Rural Households' Behavior under Market Failures*, volume 1 of *Economic Studies in Inequality, Social Exclusion and Well-Being*, chapter 9, pages 155–181. Springer US.

Jayne, T. S. (1994). Do high food marketing costs constrain cash crop production? evidence from zimbabwe. *Economic Development and Cultural Change*, pages 387–402.

Jones, A. M. (1992). A note on computation of the double-hurdle model with dependence with an application to tobacco expenditure. *Bulletin of Economic Research*, 44(1):67–74.

Key, N., Sadoulet, E., and De Janvry, A. (2000). Transactions costs and agricultural household supply response. *American Journal of Agricultural Economics*, 82(2):245–259.

Kinnan, C. and Townsend, R. (2012). Kinship and financial networks, formal financial access, and risk reduction. *The American Economic Review*, 102(3):289–293.

Kochar, A. (1995). Explaining household vulnerability to idiosyncratic income shocks. *The American Economic Review*, 85(2):159–164.

Kochar, A. (1999). Smoothing consumption by smoothing income: hours-of-work responses to idiosyncratic agricultural shocks in rural india. *Review of Economics and Statistics*, 81(1):50–61.

Krishnan, P. and Shaorshadze, I. (2015). Mis-measurement and social networks: Evidence from survey and census data in ethiopia.

Kurosaki, T. and Fafchamps, M. (2002). Insurance market efficiency and crop choices in pakistan. *Journal of Development Economics*, 67(2):419–453.

LaFave, D. and Thomas, D. (2014). Farms, families, and markets: New evidence on agricultural labor markets. Technical report, National Bureau of Economic Research, Inc.

Larson, D. F., Anderson, J. R., and Varangis, P. (2004). Policies on managing risk in agricultural markets. *The World Bank Research Observer*, 19(2):199–230.

Lau, L. J., Lin, W.-L., and Yotopoulos, P. A. (1978). The linear logarithmic expenditure system: An application to consumption-leisure choice. *Econometrica: Journal of the Econometric Society*, pages 843–868.

Ligon, E., Thomas, J., and Worrall, T. (1998). Mutual insurance, individual savings and limited commitment. Technical report, Department of Economics, Keele University.

Ligon, E., Thomas, J. P., and Worrall, T. (2000). Mutual insurance, individual savings, and limited commitment. *Review of Economic Dynamics*, 3(2):216–246.

Ligon, E., Thomas, J. P., and Worrall, T. (2002). Informal insurance arrangements with limited commitment: Theory and evidence from village economies. *The Review of Economic Studies*, 69(1):209–244.

Long, J. S. and Freese, J. (2006). *Regression models for categorical dependent variables using Stata*. Stata press.

Lopez, R. (1986). Structural models of the farm household that allow for interdependent utility and profit maximization decisions. *Agricultural household models: Extensions, applications, and policy*, pages 306–326.

Lopez, R. E. (1984). Estimating labor supply and production decisions of self-employed farm producers. *European Economic Review*, 24(1):61–82.

Mace, B. J. (1991). Full insurance in the presence of aggregate uncertainty. *Journal of Political Economy*, pages 928–956.

Maertens, A. and Barrett, C. B. (2013). Measuring social networks' effects on agricultural technology adoption. *American Journal of Agricultural Economics*, 95(2):353–359.

Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The review of economic studies*, 60(3):531–542.

Mazunda, J., Kankwamba, H., and Pauw, K. (2015). *Food and Nutrition Security Implications of Crop Diversification in Malawi's farm households. In Mapping the Linkages between Agriculture, food security and Nutrition in Malawi.* International Food Policy Research Institute Washington (IFPRI).

McFadden, D. (1980). Econometric models for probabilistic choice among products. *Journal of Business*, pages S13–S29.

McFadden, D. and Train, K. (2000). Mixed mnl models for discrete response. *Journal of applied Econometrics*, 15(5):447–470.

Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural bangladesh. *Food policy*, 32(3):372–393.

Minot, N. et al. (1999). Effects of transaction costs on supply response and marketed surplus. Technical report, International Food Policy Research Institute (IFPRI).

Minot, N. and Sawyer, B. (2013). Input use in ethiopia: Results of the 2012 ata baseline survey. Technical report, International Food Policy Research Institute (IFPRI).

Morduch, J. (1990). Risk, production and saving: Theory and evidence from indian households. *Harvard University, Manuscript*.

Morris, M. L. (2007). *Fertilizer use in African agriculture: Lessons learned and good practice guidelines*. World bank Publications.

Moser, C. O. (1998). The asset vulnerability framework: reassessing urban poverty reduction strategies. *World development*, 26(1):1–19.

Mundlak, Y. (1978). On the pooling of time series and cross section data. *Econometrica*, 46(1):69–85.

Munshi, K. (2011). Strength in numbers: Networks as a solution to occupational traps. *The Review of Economic Studies*, 78(3):1069–1101.

Munshi, K. and Rosenzweig, M. (2016). Networks and misallocation: Insurance, migration, and the rural-urban wage gap. *The American Economic Review*, 106(1):46–98.

Murgai, R., Winters, P., Sadoulet, E., and De Janvry, A. (2002). Localized and incomplete mutual insurance. *Journal of development Economics*, 67(2):245–274.

Neary, J. P. and Roberts, K. W. (1980). The theory of household behaviour under rationing. *European economic review*, 13(1):25–42.

Omamo, S. W. (1998a). Farm to market transaction costs and specialisation in small scale agriculture: Explorations with a non-separable household model. *The Journal of Development Studies*, 35(2):152–163.

Omamo, S. W. (1998b). Transport costs and smallholder cropping choices: An application to siaya district, kenya. *American Journal of Agricultural Economics*, 80(1):116–123.

Osborne, T. (2005). Imperfect competition in agricultural markets: evidence from ethiopia. *Journal of Development Economics*, 76(2):405–428.

Pan, L. (2009). Risk pooling through transfers in rural ethiopia.

Park, A. (2006). Risk and household grain management in developing countries. *The Economic Journal*, 116(514):1088–1115.

Paxson, C. H. (1992). Using weather variability to estimate the response of savings to transitory income in thailand. *The American Economic Review*, pages 15–33.

Porter, C. (2012a). Shocks, consumption and income diversification in rural ethiopia. *Journal of Development Studies*, 48(9):1209–1222.

Porter, C. (2012b). Shocks, consumption and income diversification in rural ethiopia. *Journal of Development Studies*, 48(9):1209–1222.

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in africa. *World development*, 25(5):735–747.

Renkow, M. (1990). Household inventories and marketed surplus in semisubsistence agriculture. *American Journal of Agricultural Economics*, 72(3):664–675.

Renkow, M., Hallstrom, D. G., and Karanja, D. D. (2004). Rural infrastructure, transactions costs and market participation in kenya. *Journal of Development Economics*, 73(1):349–367.

Ricker-Gilbert, J. and Jayne, T. S. (2009). Do fertilizer subsidies affect the demand for commercial fertilizer? an example from malawi. Technical report, International Association of Agricultural Economists.

Ricker-Gilbert, J., Jayne, T. S., and Chirwa, E. (2011). Subsidies and crowding out: A double-hurdle model of fertilizer demand in malawi. *American Journal of Agricultural Economics*, 93(1):26–42.

Rosenzweig, M. R. (1980). Neoclassical theory and the optimizing peasant: An econometric analysis of market family labor supply in a developing country. *The Quarterly Journal of Economics*, 94(1):31–55.

Rosenzweig, M. R. and Wolpin, K. I. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in india. *Journal of political economy*, pages 223–244.

Sadoulet, E. and De Janvry, A. (1995a). *Quantitative Development Policy Analysis*. Johns Hopkins University Press.

Sadoulet, E. and De Janvry, A. (1995b). *Quantitative development policy analysis*. Number 338.9011 S3. Johns Hopkins University Press Baltimore.

Sadoulet, E., De Janvry, A., and Benjamin, C. (1998). Household behavior with imperfect labor markets. *Industrial Relations: A Journal of Economy and Society*, 37(1):85–108.

Saha, A. and Stroud, J. (1994). A household model of on-farm storage under price risk. *American Journal of Agricultural Economics*, 76(3):522–534.

Singh, I., Janakiram, S., et al. (1986a). Agricultural household modeling in a multicrop environment: case studies in korea and nigeria.

Singh, I., Squire, L., and Strauss, J. (1986b). A survey of agricultural household models: Recent findings and policy implications. *The World Bank Economic Review*, 1(1):149–179.

Singh, I., Squire, L., and Strauss, J. (1986c). A survey of agricultural household models: Recent findings and policy implications. *The World Bank Economic Review*, 1(1):149–179.

Singh, I., Squire, L., Strauss, J., and Bank, W. (1986d). *Agricultural Household Models: Extensions, Applications, and Policy*. Johns Hopkins University Press.

Skoufias, E. (1994). Using shadow wages to estimate labor supply of agricultural households. *American Journal of Agricultural Economics*, 76(2):215–227.

Skoufias, E. (1995). Household resources, transaction costs, and adjustment through land tenancy. *Land Economics*, pages 42–56.

Skoufias, E., Bandyopadhyay, S., and Olivieri, S. (2017). Occupational diversification as an adaptation to rainfall variability in rural india. *Agricultural Economics*, 48(1):77–89.

Staal, S., Delgado, C., and Nicholson, C. (1997). Smallholder dairying under transactions costs in east africa. *World development*, 25(5):779–794.

Stiglitz, J. E. (1989). Markets, market failures, and development. *The American Economic Review*, pages 197–203.

Strauss, J. (1984a). Joint determination of food consumption and production in rural sierra leone: Estimates of a household-firm model. *Journal of Development Economics*, 14(1):77–103.

Strauss, J. (1984b). Marketed surpluses of agricultural households in sierra leone. *American Journal of Agricultural Economics*, 66(3):321–331.

Taffesse, A. S., Dorosh, P. A., and Asrat, S. (2011). Crop production in ethiopia: Regional patterns and trends. Technical report, International Food Policy Research Institute (IFPRI).

Taylor, J. E. and Adelman, I. (2003). Agricultural household models: Genesis, evolution, and extensions. *Review of Economics of the Household*, 1(1-2):33–58.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica: journal of the Econometric Society*, pages 24–36.

Townsend, R. M. (1994). Risk and insurance in village india. *Econometrica: Journal of the Econometric Society*, pages 539–591.

Townsend, R. M. (1995). Consumption insurance: An evaluation of risk-bearing systems in low-income economies. *The Journal of Economic Perspectives*, 9(3):83–102.

Train, K. (2003). *Discrete Choice Methods with Simulation*. Cambridge University Press.

Train, K. E. (2008). Em algorithms for nonparametric estimation of mixing distributions. *Journal of Choice Modelling*, 1(1):40–69.

Train, K. E. (2009). *Discrete choice methods with simulation*. Cambridge university press.

Udry, C. (1994). Risk and insurance in a rural credit market: An empirical investigation in northern nigeria. *The Review of Economic Studies*, 61(3):495–526.

Vakis, R., Sadoulet, E., and De Janvry, A. (2003). Measuring transactions costs from observed behavior: Market choices in peru. *Department of Agricultural & Resource Economics, UCB*.

Van Dusen, M. and Taylor, J. E. (2005). Missing markets and crop diversity: evidence from mexico. *Environment and Development Economics*, 10(04):513–531.

Von Braun, J. and Kennedy, E. (1986). *Commercialization of subsistence agriculture: Income and nutritional effects in developing countries*. International Food Policy Research Institute Washingtonˆ eD. CDC.

Weber, M. T., Staatz, J. M., Crawford, E. W., Bernsten, R. H., and Holtzman, J. S. (1988). Informing food security decisions in africa: Empirical analysis and policy dialogue. *American Journal of Agricultural Economics*, 70(5):1044–1052.

Wooldridge, J. (2003). *Introductory econometrics: A modern approach*. Cengage Learning.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.

Yoshimi, K., Pan, A., et al. (1978). A microeconomic analysis of production behavior of the farm household in japan-a profit function approach. *Economic Review*, 29(2):116–129.